I-93/I-95 INTERCHANGE TRANSPORTATION STUDY

Final Report - June 2007

Massachusetts Executive Office of Transportation
Office of Transportation Planning

Deval L. Patrick, ***Governor***
Timothy P. Murray, ***Lieutenant Governor***
Bernard Cohen, ***Secretary of Transportation***
Luisa Paiewonsky, ***MassHighway Commissioner***

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in cooperation with

Prepared by

The Louis Berger Group, Inc.

in association with

Howard/Stein-Hudson Associates, Inc.

TrafInfo Communications, Inc.

TranSystems Corporation

K.M. Chng Environmental Inc.

Von Grossmann & Company

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EXECUTIVE SUMMARY

The I-93/I-95 Interchange is a major part of the regional highway system and a key to the economy of the Commonwealth. Severe congestion and safety problems exist at the interchange, due mainly to its very short weaving distances and other substandard geometry. The interchange carries more traffic than any other in New England (over 375,000 vehicles per day), and projected increases in future traffic would make the problems even worse at this "bottleneck" congested location. This location has the highest crash rate (accidents per million vehicles) of any similar interchange in Massachusetts, with many crash clusters in the interchange coinciding with the geometric deficiencies. Furthermore, its close proximity to other interchanges (especially Washington Street on I-95/Route 128) compounds the problems and necessitates inclusion of some adjacent interchanges as part of the proposed solutions.

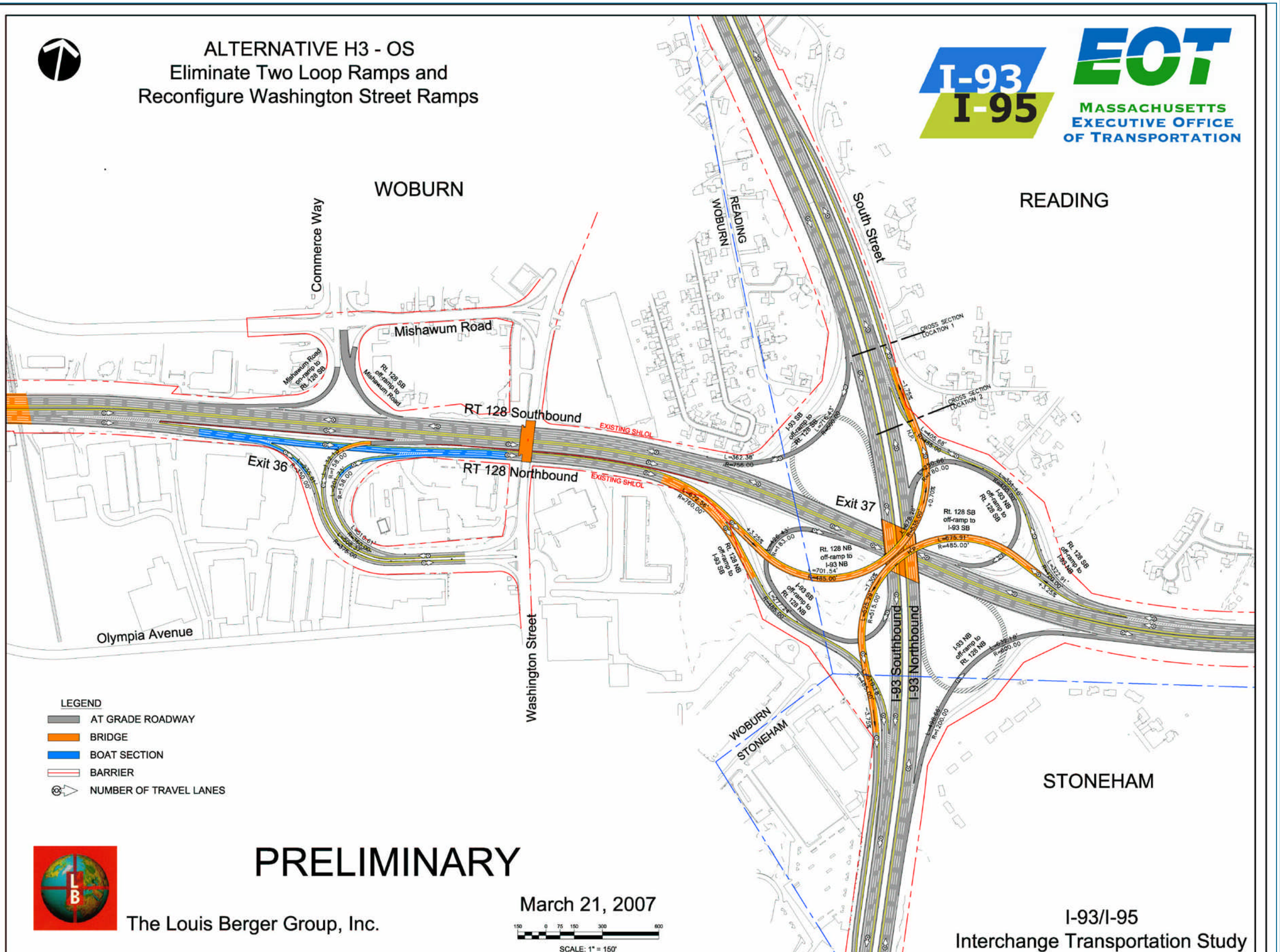
The interchange is closely bordered by residential neighborhoods in Reading, Stoneham, and Woburn, and by a major employment area in Woburn. After a previous engineering design feasibility study was strongly opposed by the communities due to potential property takings and other impacts; the Massachusetts Executive Office of Transportation (EOT) worked to form an Interchange Task Force (ITF) to guide the present planning study.

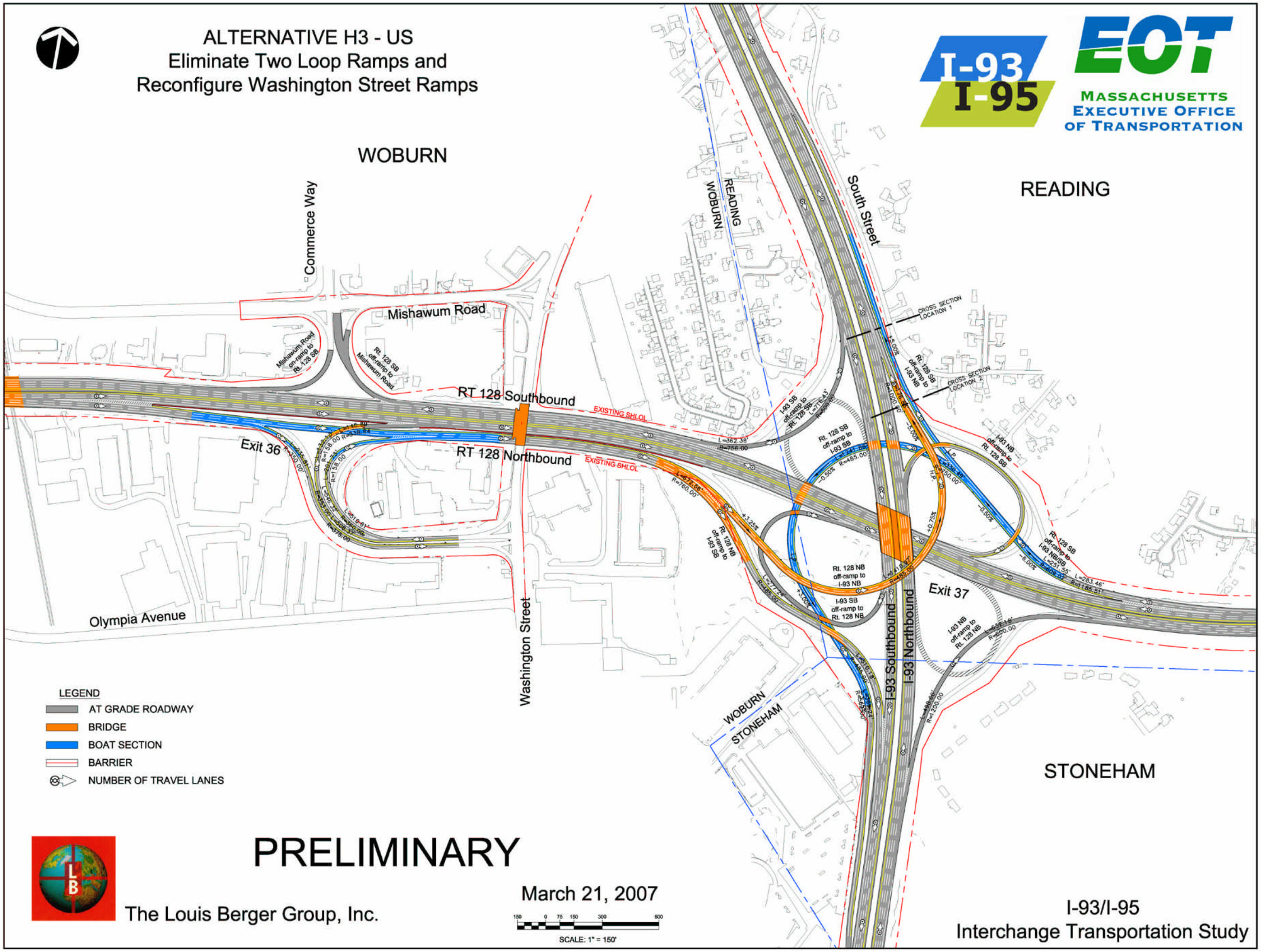
The Interchange Task Force was composed of residents, businesses, local officials, legislators, and other organizations representing a variety of stakeholders. Working in close cooperation with EOT, MassHighway, the MBTA, and other agencies, the ITF was a principal partner in developing the study's recommendations. Public Participation was a key part of EOT's open and inclusive study process. In addition to over three dozen meetings with the ITF, three major public informational meetings were held, newsletters were distributed, the study was covered by local newspapers and community television, and an informational web site (www.9395info.com) was updated continuously throughout the study.

Two important principles guided the study: the solutions proposed must be sensitive to the surrounding communities ("context-sensitive design") and they must include both highway and non-highway components. From the beginning, the ITF strongly supported the study goals of avoiding property takings (particularly residential takings), and minimizing noise and visual impacts. It was established during development of the alternatives that major takings would be unavoidable with a 50 mph ramp design speed but could be avoided with a 40 mph design. Discussions were held with the Federal Highway Administration and MassHighway on a design exception to allow for improvements based on the 40 mph speed. Although the recommended alternatives identify small, partial property takings in the northeast and southwest quadrants, no residence or business would be taken. In addition, it was an important ITF objective to maintain direct local access to and from the interstate highways at all locations, and this access is indeed preserved with the recommended alternatives.

The study looked at 16 highway improvement components (initially tested with a regional travel demand model) and reduced these to four alternatives for evaluation. This resulted in a selection of two versions of the most promising alternative (H3-OS and H3-US) for further engineering and environmental analysis in the next phase of project development. Both versions remove the northwest and southeast loop ramps, removing all weaves and provide a northbound connector road to I-93 with split ramps from Washington Street to remove the weave to I-93. Further variations and refinements of these alternatives should be explored in the upcoming environmental phase before a selection is made, but it should be recognized that an extensive screening process with the ITF resulted in the recommendation of the "H3" alternative with its two variations.

On the non-highway side, a package of 11 transit and Transportation Demand Management (TDM) improvements was targeted at the travel markets in the study area, tested with the regional travel demand model, and recommended for the environmental phase as an integral part of the proposed solutions. Longer range recommendations on intelligent transportation systems, high-occupancy vehicle lanes, and land use policies are also recommended for future study.


ALTERNATIVE H3 - OS
Eliminate Two Loop Ramps and
Reconfigure Washington Street Ramps
I-93
I-95
EOT
MASSACHUSETTS
EXECUTIVE OFFICE
OF TRANSPORTATION
WOBURN
READING
STONEHAM
Commerce Way
Mishawum Road
South Street
RT 128 Southbound
RT 128 Northbound
Exit 36
Exit 37
Washington Street
Olympia Avenue
I-93 Southbound
I-93 Northbound
EXISTING SHLOL
LEGEND
AT GRADE ROADWAY
BRIDGE
BOAT SECTION
BARRIER
NUMBER OF TRAVEL LANES
PRELIMINARY
The Louis Berger Group, Inc.
March 21, 2007
SCALE: 1" = 150'
I-93/I-95
Interchange Transportation Study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Rendering of Alternative H3-OS, looking northeast from Woburn toward Reading.

Rendering of Alternative H3-US, looking northeast from Woburn toward Reading.

The next step in improving the interchange is the state and federal environmental process for both highway and non-highway improvements. The environmental documents should include further detailed analyses for the 40 mph design exception, and analyses for noise impacts in the surrounding areas to help determine the priority and locations of noise mitigation measures (including the potential for noise barriers prior to interchange construction).

The cost of the recommended highway alternatives (including noise barriers and interim improvements) is $160 million for H3-OS and $249 million for H3-US. The total capital cost of the recommended transit and TDM improvements is $20.2 million, and the total first-year operating cost is $7.1 million. (Total range = $187 to $276 million - for details, see pages 93-94.)

Recommendations

1. The alternatives to be advanced for environmental study should include both the split Washington Street Ramps and a northbound Route 128 connector road to I-93.

2. Alternatives H3-OS and H3-US should be given equal scrutiny to explore construction sequences, refine costs, and establish comparative noise, visual, and wetland impacts in detail. The appropriate place to answer these remaining questions and select a final highway alternative is in the environmental study which must follow the planning study.

3. During the environmental phase, further engineering should be done to explore variations that can improve the two alternatives and reduce their impact.

4. Extension of the fourth lane on Route 128 northbound to Exit 40 (Route 129), and on Route 128 southbound from Exit 38 (Route 28) should be implemented as an interim improvement, along with an on-ramp from Cedar Street in Woburn to southbound I-93. Where warranted by MassHighway noise abatement guidelines, noise barriers should be constructed as part of the interim improvements, adjacent to the added lanes on Route 128 and also at other locations around the I-93/I-95 Interchange where barrier relocation would not be required during construction of full improvements.

5. All transit and TDM improvements described in Chapter 3 should be included with the recommended highway improvements in an integrated multi-modal package of actions to be further developed and analyzed in the environmental phase.

6. The highway and non-highway recommendations of the I-93/I-95 Interchange Study have been conceived, evaluated, and discussed with the Interchange Task Force as a multi-modal integrated package of improvements. Therefore, this package, including interim improvements, should be developed and evaluated in a single environmental study, resulting in an Environmental Impact Report and Statement that addresses the entire package.

7. The environmental studies should be based on a continued, open process of public involvement and should be prepared in coordination with an ongoing Citizens Advisory Committee incorporating the members and interests of the I-93/ I-95 Interchange Task Force and the affected communities. Minimizing takings, noise, and visual impacts are essential to maintaining community support.

8. A study of long range ITS improvements should be undertaken to address information systems, ramp metering, and variable speed limits as potential techniques to better manage congestion on the region's expressways.

9. Because of the scale and complexity of the problem and because of its importance to long range mobility, energy conservation, and greenhouse gas reduction, a long-range regional HOV study is also recommended.

10. The I-93/I-/95 Interchange Transportation Study recommends incorporating regional and local land use planning efforts (such as MAPC's MetroFuture initiative) into transportation project planning, and encourages the full participation of Reading, Stoneham, Woburn, other local communities, and regional organizations in the planning process.

INTRODUCTION

Why is it important to improve the I-93/I-95 Interchange?

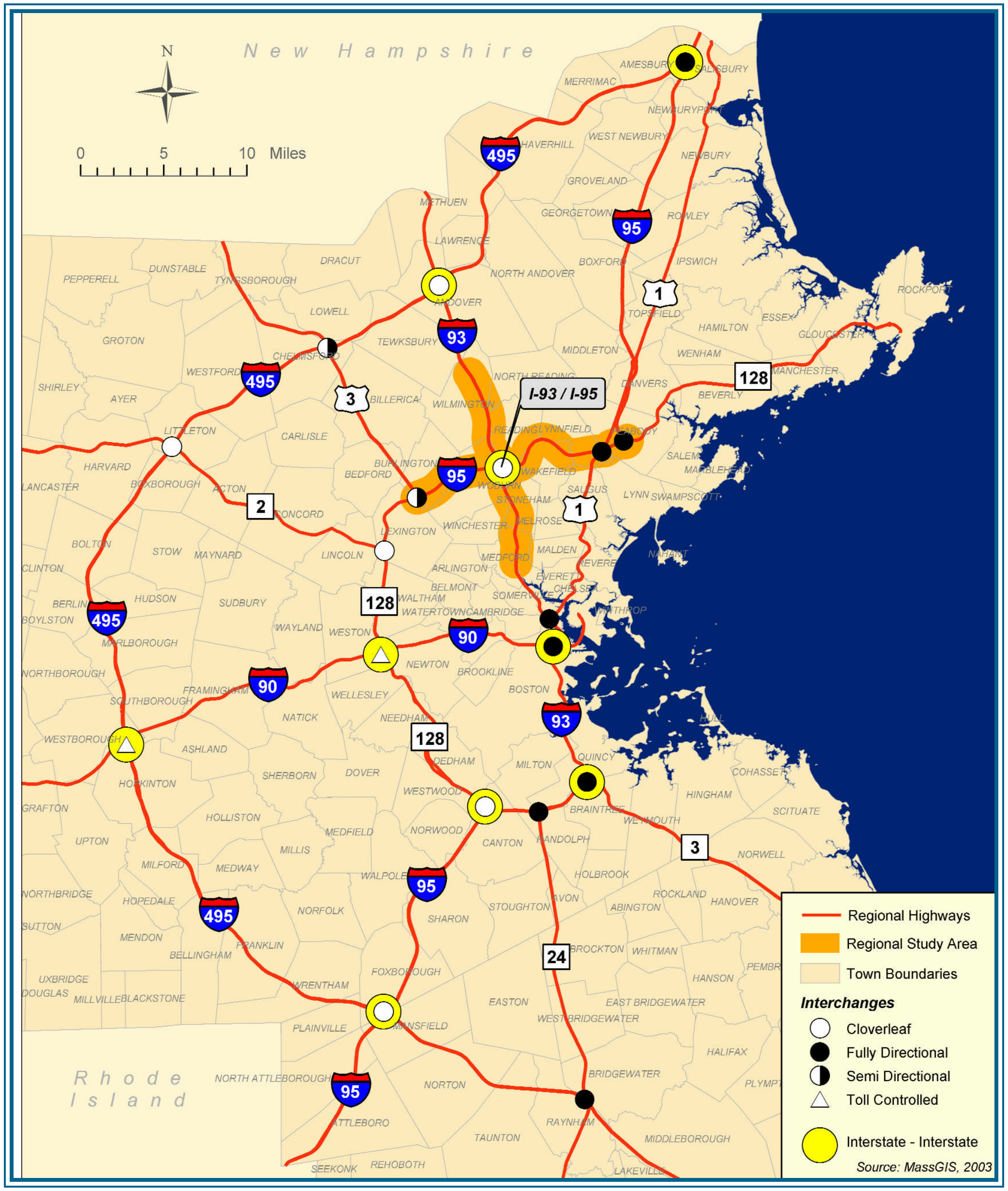
System Interchange

Solving the problems at the I-93/I-95 Interchange is a high priority for the Commonwealth of Massachusetts. The I-93/I-95 Interchange is the funnel for "commute-shed" north and northeast of Boston. It is a “system” interchange where two of New England's major interstate highways intersect: Interstate 93 which connects Boston to the northern tier of cities and towns and New Hampshire and Interstate 95 the major spine which connects all of the states on the eastern seaboard. I-95 (Route 128) is the beltway that serves a large proportion of the metropolitan area's residents with access to major employment and shopping centers. This system interchange serves as a vital link for the movement of people and goods, and it is a key to the economy of the region.

Very High Volumes

The interchange processes more traffic than any other in Massachusetts and in New England as well. In 2004 a total of 377,500 vehicles used the interchange on an average weekday. Entering volumes ranged from 83,000 per weekday on Route 128 southbound to 105,000 vehicles on I-93 northbound. This location is a “bottleneck” for traffic from all directions, resulting in heavy congestion and significant delays on a daily basis.

Figure IN-1: System Interchanges in the Eastern Massachusetts Region.



High Crash Rate

The I-93/I-95 interchange is consistently one of the top 10 locations in Massachusetts in terms of number of crashes. This is due in part to the very high traffic volumes that use the interchange, but controlling for volume, the interchange has the highest crash rate of any similar cloverleaf interchange in Massachusetts. Vehicle crashes (commonly referred to as accidents) and the details of their occurrences at the interchange are discussed in Chapter 2.

The area in the southwest quadrant of the interchange and immediately to the west is a major regional business district with shopping, offices, and light industrial and warehouse uses. Direct, reliable local access is of greatest concern to the City of Woburn and the businesses within this area. There are also residential enclaves within this largely business area that share the concerns of the other neighborhoods in the area.

Major local streets are impacted by traffic that diverts from the interstate highways due to congestion. The most affected streets are Route 129, Main Street, South Street and West Street in Reading; Route 28 and Montvale Avenue in Stoneham, and Washington Street, Mishawum Road, and Olympia Avenue in Woburn.

Context

The municipal boundaries of the City of Woburn and the towns of Reading and Stoneham come together at the interchange, which is closely bordered by residential neighborhoods on three sides: Richard Circle and Border Road in the northwest, South Street and adjacent streets in the northeast, and Constitution Road/Crosby Road in the southeast. Residential properties directly abut the highway right-of-way in these three quadrants. Understandably, residents of these neighborhoods are concerned by the possibility of property takings to expand the interchange and by existing and potential noise, visual, and air quality impacts and local traffic.

Route 128.

Figure IN-2: Aerial View of the I-93/I-95 Interchange, looking from northeast to southwest.

Background

The Commonwealth's Role

The Executive Office of Transportation, Office of Transportation Planning (EOT Planning) is directing the I-93/I-95 Interchange Transportation Study. EOT Planning is working in cooperation with the Massachusetts Highway Department (MassHighway, which maintains the state's highways, constructs improvements, and collects data on traffic volumes and accidents), and with the Boston Metropolitan Planning Organization (MPO). The Boston MPO is the organization vested by federal and state law with responsibility to set priorities for transportation projects and program the available funding for these projects. The study is also supported by the Central Transportation Planning Staff (CTPS), the technical arm of the Boston MPO. CTPS conducted regional transportation demand modeling for the study.

Previous MassHighway Feasibility Study

From 2000 to 2002, MassHighway directed a "design feasibility" study of the I-93/I-95 Interchange. This study focused on highway engineering improvements for the interchange, but received strong opposition in all three municipalities owing in part to residential takings that would have resulted from the alternatives under consideration. The alternatives proposed (including ramp flyovers) that best improved traffic flow and safety would have required the most property takings. There was also dissatisfaction with the extent of public involvement in the feasibility study.

In September 2002, MassHighway suspended the feasibility study, and EOT Planning was directed to lead a revised effort with an advisory Interchange Task Force (ITF). In the initial ITF meetings, EOT Planning outlined the revised study process and established the role of the ITF. EOT and the Task Force worked together to develop a scope of work for the study. In early 2004, after a thorough and systematic consultant selection process with substantial Task Force input, the Louis Berger Group (LBG) was selected to conduct the study.

Roadmap for the Study

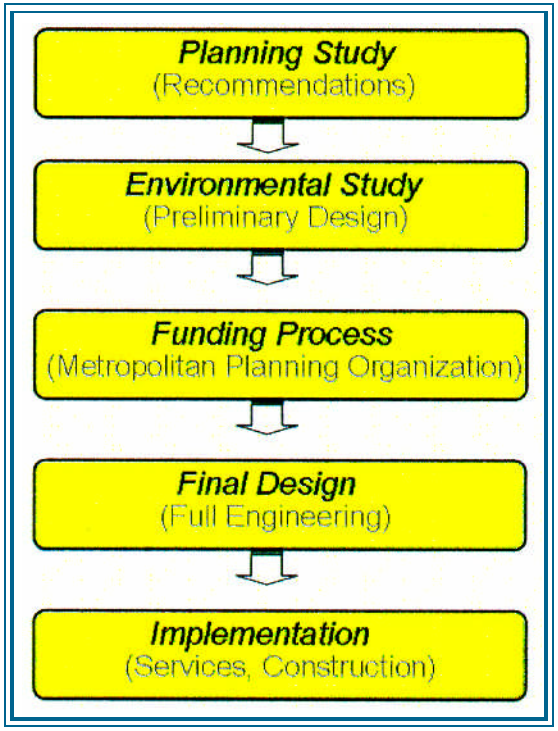
The I-93/I-95 Interchange Transportation Study is a planning study that is not limited to engineering solutions. It considers both the local and regional context of the interchange, and it emphasizes public involvement.

The study consists of the following steps:

- Develop an understanding of the problem
- Propose alternatives to fix the problem
- Evaluate the alternatives
- Make recommendations

These steps are documented in the four chapters of this report.

Figure IN-3: Phases in Improving the Interchange.



It is important to understand that the I-93/I-95 Interchange Study is the first of five phases to remedy problems at the interchange. These phases are shown in Figure 1N-3. The first step following the study will be a detailed environmental analysis based on preliminary design of highway improvements and other transportation actions such as transit and transportation demand management (TDM). Although environmental impacts were considered and conceptual engineering was done in the current planning study, the scope of both these activities is necessarily less than needed to satisfy environmental regulations in the

following steps. Therefore, the conclusions and recommendations of the planning study are preliminary and must be tested and further developed in the following step. The recommendations in Chapter 4 reflect this and include specific items requiring further engineering and environmental work.

Public Involvement Process

EOT is committed to providing meaningful public involvement throughout the study. The process has two major parts:

- In-depth work with the Interchange Task Force representing federal, state and local officials, residents, businesses, and other agencies and organizations.
- Two-way communication with the wider public.

Interchange Task Force

The Interchange Task Force (ITF) met approximately monthly with EOT Planning and the Consultants in meetings that were open to the public and frequently reported in newspapers and television. A total of 44 meetings were held, including 12 meetings with task-oriented subcommittees of the ITF. Summaries of all meetings were posted soon afterward on the study web site. Table IN-1 lists the members of the task force. Input from the ITF meetings was an important part of the study process, and the consultant team and EOT maintained a list of issues and requests for information that arose in the task force meetings, and responded to these items as the study went forward. As noted in subsequent chapters, the ITF played a critical role in shaping the study and its outcome.

Table IN-1: Interchange Task Force Roster

AFFILIATION	NAME
Reading Board of Selectmen	Camille Anthony
Reading Board of Selectmen	Rick Schubert
Reading Citizen Representative	George Katsoufis
Reading Community Planning and Development Commission	Jonathan Barnes
Reading- N.Reading Chamber of Commerce	Joe DiBlasi
Stoneham Board of Selectmen	Anthony Kennedy
Stoneham Town Administrator	David Ragucci
Stoneham Public Works	Robert Grover
Stoneham Citizen Representative	Suzanne Smith
Woburn Mayor	Tom McLaughlin
Woburn Business Association	Paul Meaney
Woburn Citizen Representative	Paul Medeiros
Woburn City Council	Darlene Bruen
Woburn City Engineer	John Corey
Woburn Planning Director	Ed Tarallo
Wakefield DPW Director	Richard Stinson
State Senator	Robert Havern
State Senator	Richard Tisei
State Representative	Paul Casey
State Representative	Patrick Natale
State Representative	Michael Festa
State Representative	Bradley Jones
Metropolitan Area Planning Council	Jim Gallagher
PRESERVE	Jeff Everson
THAG	Bill Webster
Eastern Middlesex Board of Realtors	Eileen Hamblin
North Suburban MA. Chamber of Commerce	Maureen Rogers
Cummings Properties	Dennis Clarke
AAA- Southern New England	Art Kinsman
Federal Highway Administration	Josh Grzegorzewski
Federal Transit Administration	Andrew Motter
MA. Motor Transportation Association	Dan Sullivan
MassPort	Craig Leiner
MassRides	Ian Durrant
MBTA	Joe Cosgrove

Meetings were attended by senior consultant team members including EOT Planning project manager Bob Frey and LBG project manager Jim Purdy. Kathy Stein of Howard/Stein Hudson Associates facilitated most meetings. ITF members agreed at an early date on a set of ground rules to govern the meetings, and these norms were observed throughout the study.

Ground Rules for the Interchange Task Force

Guidance for ITF Meeting Participation

- Start and end on time.
- Agree to follow the agenda.
- Avoid making long speeches - commit to having a dialogue instead.
- Address each other respectfully.
- Turn off cell phones and beepers.
- Think win-win.
- Avoid dwelling on the past - reference the past to learn from it.
- Agree to disagree when necessary and move on.
- Respect the opinions of all members as people bring different viewpoints.
- Be willing to compromise to reach solutions.

Guidance for the Study Process

- Capture the major issues and accomplishments from one meeting to the next.
- Use subcommittees as a way to work on issues.
- Periodically dedicate time during ITF meetings to brainstorming to encourage creative thinking.
- Maintain a list of open issues and address each issue when the information is available.
- Include follow-up actions in list of open issues. Keep ITF members informed of status of open/closed issues.

Involving the Wider Public

In order to provide information to the wider public and receive input from them, a series of mechanisms was used:

- Public informational meetings were held in April and October of 2006, and in March of 2007. They were well attended with an approximate total of 500 people combined. The meetings presented information about the problems, alternatives and their evaluation, and proposed recommendations. There was ample time at each meeting for questions and responses. Meetings were professionally facilitated by Kathy Stein to ensure that everyone had an opportunity to speak. Presentations and meeting summaries were posted to the web site after each meeting. Flyers and meeting announcements were used to encourage turnout and ITF members worked to get news of the meetings to their constituents. Articles in major regional and local newspapers were published in advance of each meeting. For the second and third meetings, variable message signs announcing the meetings were placed on I-93 and Route 128. Meetings were covered by local cable television in the host community and video recordings were distributed to the other communities for rebroadcast by local access TV.

Public meeting summaries are included in the Appendix to this report, and input received is noted in Chapters 2, 4, and 5.

- Newsletters were prepared in advance of each meeting, distributed at the meetings, and posted to the website.
- Media Coverage. EOT worked with the media to provide access and information for reporters. ITF meetings and public meetings were regularly reported in detail in the Woburn Daily Times Chronicle, Stoneham Sun, Reading Advocate, and other local papers. The three major public informational meetings were the subjects of articles in the Boston Sunday Globe, each published three days before each meeting.

Study Website.
A website, www.9395info.com, was set up early in the project. This web site carried meeting announcements, background information, downloadable documents and images (including summaries of all meetings), and contact information for the study team and the ITF. The website permits visitors to post comments and view the comments of others. Visitors can also contact the study team directly with questions. Figure IN-5 shows statistics on the use of the website in the first 18 weeks of 2007. Over this period, the site averaged 230 visitors per week. Approximately 87 percent of the visitors over this period were new to the site. The average visit involved looking at between three and four pages of the site, averaging approximately one minute per page. The chart shows that website visits were strongly related to the public information campaign to publicize the public information meeting held in Week 12, with over 100 visitors per day around the meeting date (March 21, 2007).

- Strategic Partnership Plan. An early task was development with the ITF of a plan for public involvement, including all of the elements described above. The plan was updated during the course of the study as needed. The plan is included in Appendix A to this report.

Figure IN-4: Home Page of www.9395info.com Website.

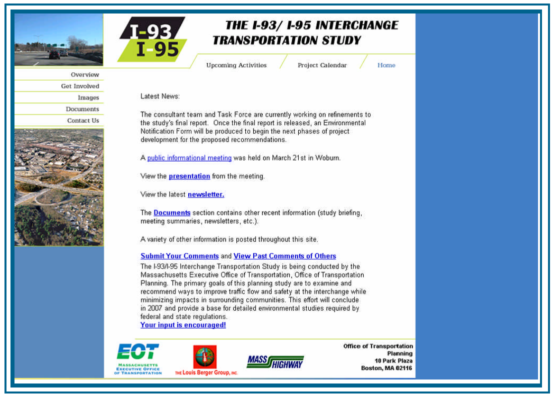
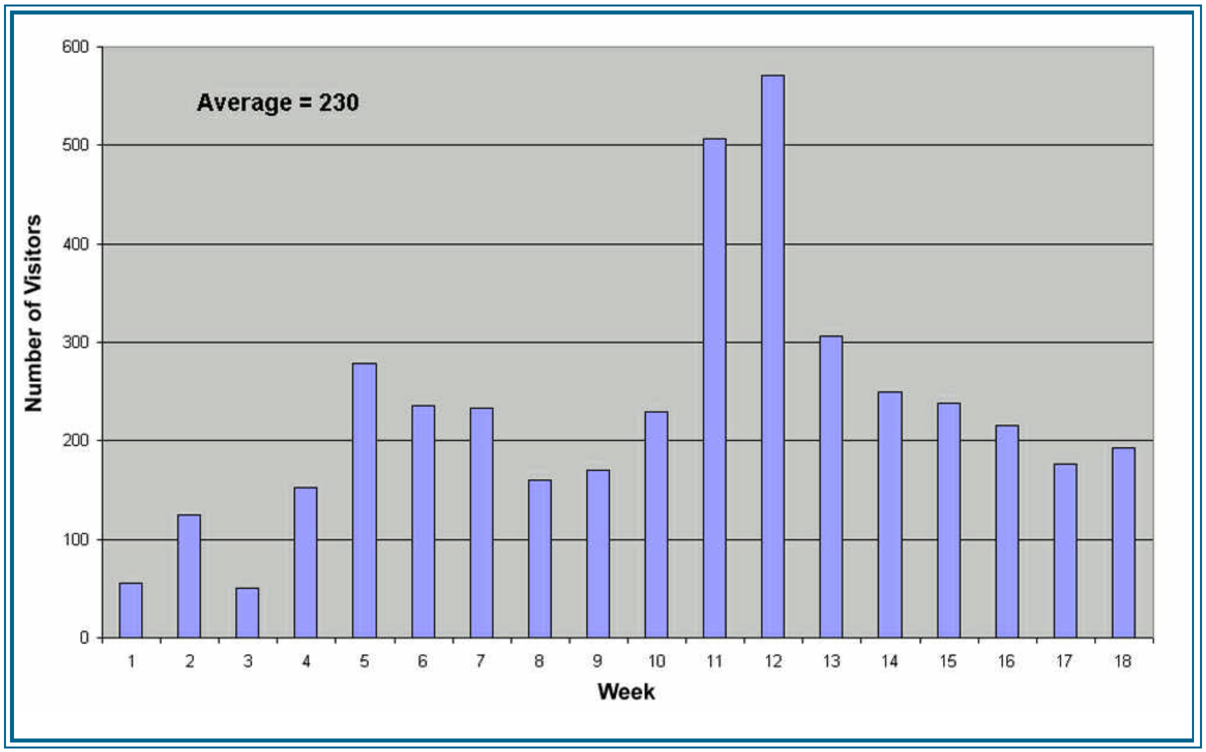


Figure IN-5: Study Website Utilization, January - April 2007.



1. FRAMEWORK FOR THE STUDY

1.1 How the Framework is Used

The planning study's first task provides a framework for the subsequent tasks. This framework has four major elements:

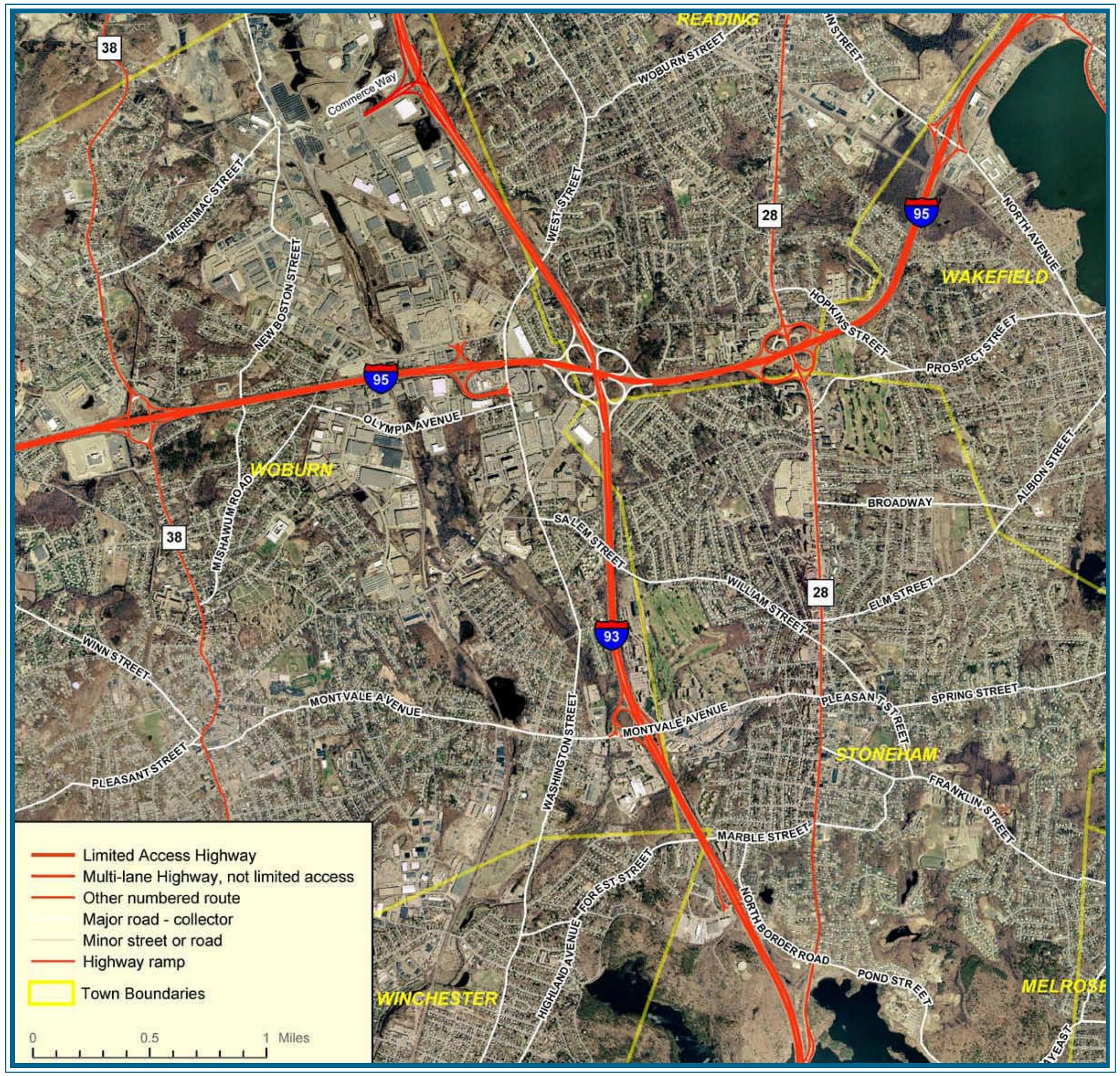
- Project Study Area
- Goals and Objectives
- Evaluation Criteria
- Public Involvement Plan

1.2 Study Area

The I-93/I-95 Interchange is at the center of a regional highway system serving Massachusetts and New England. It is also a facility of importance to the host communities of Reading, Woburn, Stoneham, and neighboring towns. The study focuses on two areas that are defined in terms of interchanges on the two interstate highways. (These interchanges are numbered along each highway from south to north. The I-93/I-95 Interchange in the center of the study area is designated as Exit 37 on both highways.)

At the larger scale, the Regional Focus Area extends along Route I-95 (Route 128) from the Route 3 interchange in Burlington (Exit 32) to the I-95/Route 128 split in Peabody (Exit 45). In the north-south direction, it extends along I-93 from the Route 125 interchange in Wilmington (Exit 41) down to the Route 60 interchange in Medford (Exit 32). Regional travel patterns were studied in this area. Figure 1-1 in the Introduction to this report shows the Regional Focus Area in relation to I-93/I-95 and the adjacent interchanges.

Figure 1-1: Local Focus Area.



The Local Focus Area extends from the I-95/Route 38 interchange in Woburn (Exit 35) in the west to the I-95/Route 129 interchange in Reading (Exit 40) in the east. In the north-south direction, it extends from the I-93/Route 129 interchange in Wilmington (Exit 38) down to the I-93/Route 28 interchange in Stoneham (Exit 34). Figure 1-1 shows the Local Focus Area. Within the Local Focus Area, the study examined traffic on the interstate highways, interchanges, and major local streets. Public transportation, pedestrian and bicycle routes, land use/development, economics, demographics, community quality of life, environmental and cultural resources were also be examined in areas near the highways in the Local Focus Area.

1.3 Goals and Objectives

Goals and objectives provide the direction for the study and the basis for evaluating study alternatives and recommendations. They were regarded by the ITF as crucial to the success of the study. Developing the goals and objectives was the subject of early ITF meetings.

Goals define the general intentions and purposes for conducting the transportation study, based on the issues that are being addressed. Objectives describe specific ways that the goals could be accomplished. There are two types of Goals and Objectives for this study: those that pertain to desired results and those that pertain to the desired process.

The following list was developed by the study team and ITF in the first three months of the study.

I. DESIRED RESULTS

A. TRANSPORTATION

Goal: Improve traffic flow in and around the I-93/I-95 Interchange.

Objectives:

a. Decrease congestion and reduce delays at the interchange with alternatives that address bottleneck locations and situations.
b. Include nearby interchanges in the analysis and in the improvements to maximize effects at the main interchange.

Goal: Improve safety for motorists.

Objectives:

a. Eliminate or improve locations and situations that pose hazards.
b. Ensure adequate weave areas, acceleration/deceleration lanes, and sight distances.

Goal: Improve local traffic conditions on local streets.

Objectives:

a. Improve traffic flow on streets receiving traffic diverted from interstate highways.
b. Maintain or enhance access serving local businesses and residences.
c. Minimize impacts to local streets that are used as alternate routes to the interstate highways.

Goal: Improve Mobility through Multi-Modal and other Transportation Strategies

Objectives:

a. Explore the provision of expanded public transportation options in the area.
b. Seek ways to improve coordination of existing transit services where possible.
c. Explore ridesharing options and High Occupancy Vehicle (HOV) use.
d. Explore options for Intelligent Transportation Systems (ITS).

B. QUALITY OF LIFE AND THE ENVIRONMENT

Goal: Meet transportation goals without sacrificing quality of life for area communities.

Objectives:

a. Minimize noise impacts on adjacent residences and other sensitive receptors.
b. Relieve impacts of cut-through traffic on neighborhoods and business districts.
c. Design improvements within the existing right-of-way as much as possible.
d. Avoid residential and business property takings as much as possible.
e. Minimize negative economic effects on tax bases, and enhance local and regional economic activity where possible.
f. Minimize visual impacts on the communities and enhance the visual environment where possible.
g. Maintain community and business district connections and access, including automobile, truck, emergency vehicle, bicycle and pedestrian access,

and make improvements where possible.

h. Consider quality of life costs as well as financial costs.

Goal: Protect and enhance the natural and cultural environment.

Objectives:

a. Avoid impacts to wetlands and water bodies.
b. Avoid impacts to wildlife habitats, particularly habitats that support threatened or endangered species.
c. Avoid local and regional air quality impacts.
d. Avoid impacts to historic and archeological resources or public parkland and conservation land.
e. Properly address any areas contaminated by hazardous materials.
f. If impacts cannot be avoided, minimize them to the greatest extent possible.

C. IMPLEMENTATION

Goal: Develop recommendations that can be implemented efficiently.

Objectives:

a. Construction impacts (to traffic flow, the surrounding quality of life and natural environment) will be minimized.
b. Recommendations should be cost-effective in the context of state transportation planning.
c. Recommendations should meet criteria for federal funding.
d. Recommendations should include both short-term and long-term actions to improve traffic flow and safety.

II. DESIRED PROCESS

A. OPEN AND INCLUSIVE PROCESS

Goal: The study will continue to be conducted through an open and inclusive process.

Objectives:

a. The input of the Interchange Task Force and the public will be documented and thoroughly considered at every stage of the study.
b. MassHighway and the ITF will attempt to reach reasonable consensus on study recommendations.
c. The adjacent communities and greater public will be informed and consulted throughout the study.
d. The general public will be kept informed, and will have opportunities to comment throughout the study.

B. DEMONSTRATION AND JUSTIFICATION OF NEEDS

1. Goal: Recommendations should address demonstrated needs.

Objectives:

a. Criteria for the needs - such as safety and traffic flow - will be quantified or qualified as clearly as possible.
b. Compare suggested recommendations to the results of other projects where feasible.
c. Provide justification for any additional recommended actions over and above what analyses show is necessary.

1.4 Evaluation Criteria

Evaluation criteria are the bridge between goals/objectives and the evaluation process for the alternatives being considered. They are specific measures - both quantitative and qualitative - that are used to assess the benefits and impacts of each alternative. These criteria were developed with the ITF and later used to provide structure to the evaluations described in Chapter 4. They are shown in Table 1-1.

1.5 Public Involvement Plan

The Strategic Partnership Plan, which governed the study process for involving the Interchange Task Force and the wider public, is described in the Introduction to this report. The partnership plan is included in Appendix A.

Public Involvement Goals:

a. To conduct the study in an inclusive manner so that all people and values are heard.
b. To educate the public and stakeholders about opportunities, issues, goals, and alternatives at the Interchange.
c. To clarify the decision-making process.
d. To create widespread awareness of the new study and opportunities to participate.
e. To engage stakeholders and secure a commitment to keep the process moving forward.

Table 1-1: Evaluation Criteria for I-93/I-95 Interchange Improvements.

Goals and Objectives of the Study	Evaluation Criteria How to Measure each Alternative? (Quantitative and Qualitative)	Comments/Source
TRANSPORTATION		
1. Traffic		
Improve flow on freeways, ramps, and local streets	Average speed (peak and off-peak)	CORSIM
	Queue lengths at key intersections. Volume/capacity at key intersections and links.	Highway Capacity Manual
Reduce the amount of recurring delay	Travel time savings	Planning Model
Improve system reliability	Number of lane changes	CORSIM
	Flow rate - pcplph	Highway Capacity Manual
	Spacing of ramps within interchange and between interchanges	Measurement
	Duration and extent of congestion	Percent of daily travel in congested conditions
	Daily vehicle miles of travel	Planning Model
Minimize local street impacts	Changes in forecast traffic volumes on key local streets	Planning Model
2. Safety		
Eliminate/improve hazardous situations	Focus on hot spots from detailed crash records	Detailed analysis of crash data
Minimize points of conflict, i.e., weaves	Number of weaves eliminated	Computation
Increase length of weaving areas	Length vs. design speed	Measurement
Increase the length of acceleration/deceleration lanes	Length vs. design speed	Measurement
Extend sight distances	Length vs. design speed	Measurement

Goals and Objectives of the Study	Evaluation Criteria How to Measure each Alternative? (Quantitative and Qualitative)	Comments/Source
3. Transit, Demand Management, Intelligent Transportation Systems		
Explore expanded public transportation	Feasibility of expanded services; reductions in bus transit delay through interchange	Mini-studies of these strategies
Improve coordination of existing transit services	Potential to improve coordinaton	
Explore ridesharing/HOV lanes	Feasibility of expanded ridesharing	
	Feasibility/effectiveness of HOV lanes	
Explore ITS	Potential for ITS improvements to improve access	
Explore ways to reduce auto dependency	Potential for programs to reduce auto dependency	
4. Physical Improvements		
Identify strategies for reconstructing or replacing existing facilities to address goals 1-3	Number of weaves modified	Measurement
	Number of ramps/loops modified	
	Number of direct connections	
	Number of roadway levels	
	Number of ramp merges/diverges	
	Number of grade-separated crossings	
	Travel speed	CORSIM
	Design speed	Measurement and Geometric Design Criteria (inc. Hwy Design Manual)
	Level of Service	Highway Capacity Manual
	Changes to highway access and changes in traffic flow on these routes	Measurement and Planning Model

Goals and Objectives of the Study	Evaluation Criteria How to Measure each Alternative? (Quantitative and Qualitative)	Comments/Source
QUALITY OF LIFE AND THE ENVIRONMENT		
Meet transportation goals without sacrificing quality of life for area communities		
Minimize noise impacts	changes in highway characteristics that affect noise levels (distance, speeds, volumes); magnitude of increase or improvement (major/moderate/minor/none); potential for noise mitigation	FHWA mitigation criteria relative to noise levels or magnitude of increase
Relieve impacts of cut-through traffic	reduction of modeled cut-through volumes; potential for improvements	
Improvements within existing ROW	Number of instances and total amount of new ROW needed	
Minimize takings		
Residential	number of full takings; number and amount of partial takings	
Business	number of full takings; number and amount of partial takings	
Minimize impacts/improve		
Tax bases	direct loss of tax base and tax rate impact	
	qualitative indirect effects on property values	
Local/regional economy	direct loss of revenues and employment	
	qualitative indirect effects on revenues & jobs	

Goals and Objectives of the Study	Evaluation Criteria How to Measure each Alternative? (Quantitative and Qualitative)	Comments/Source
QUALITY OF LIFE AND THE ENVIRONMENT		
Meet transportation goals without sacrificing quality of life for area communities		
Minimize impacts/enhance visual environment	Description of changes in views at representative locations	
Maintain/improve connections/access		
Automobile	[see business/residential access]	
Truck	[see business access]	
Emergency vehicle	Description of any improvements or impacts to emergency vehicle access	
Bicycle/pedestrian access	Description of impacts to ped/bike routes; potential for improvements	
Consider quality of life as well as financial costs	summary of evaluation	
Protect and enhance the natural and cultural environment.		
Protect wetlands	number of total wetlands affected; SF of wetland encroachment	
Protect habitats	number of total habitats affected; SF of habitat encroachment	habitat encroachment unlikely, as location is away from "Priority" and "Estimated" habitats
Improve regional and local air quality	within regional emissions targets (macro analysis)	Air Quality conformity process

Goals and Objectives of the Study	Evaluation Criteria How to Measure each Alternative? (Quantitative and Qualitative)	Comments/Source
QUALITY OF LIFE AND THE ENVIRONMENT		
Meet transportation goals without sacrificing quality of life for area communities		
Protect cultural resources		
Historic/archeological	Specific resources affected and degree.	
Parkland/conservation land.	Specific park/conservation land affected and degree.	
Properly address contaminated areas	Description of effect on any such areas and measures to appropriately address	
If impacts cannot be avoided, minimize them	Mitigation measures for selected alternative(s)	
IMPLEMENTATION		
Develop recommendations that can be implemented efficiently		
Constructability	List potential obstacles to construction of scheme and their severity	includes traffic maintenance, structures over/under active highway, etc.
Minimize construction impacts		
Traffic flow	Description of traffic maintenance measures	conceptual
Quality of life	Description, severity, and duration of construction impacts and mesures to mitigate	
Natural environment	Description, severity, and duration of construction impacts and mesures to mitigate	
Cost-effective	Conceptual cost	
Meet MassHighway Design Manual Criteria	Instances where desirable design standards problematic Instances where minimum design standards not met	
Meet federal funding criteria	Relationship to FHWA eligibility criteria	
Address both short-term and long-term actions	[apply same criteria to short term actions]	

2. DEFINING THE PROBLEM

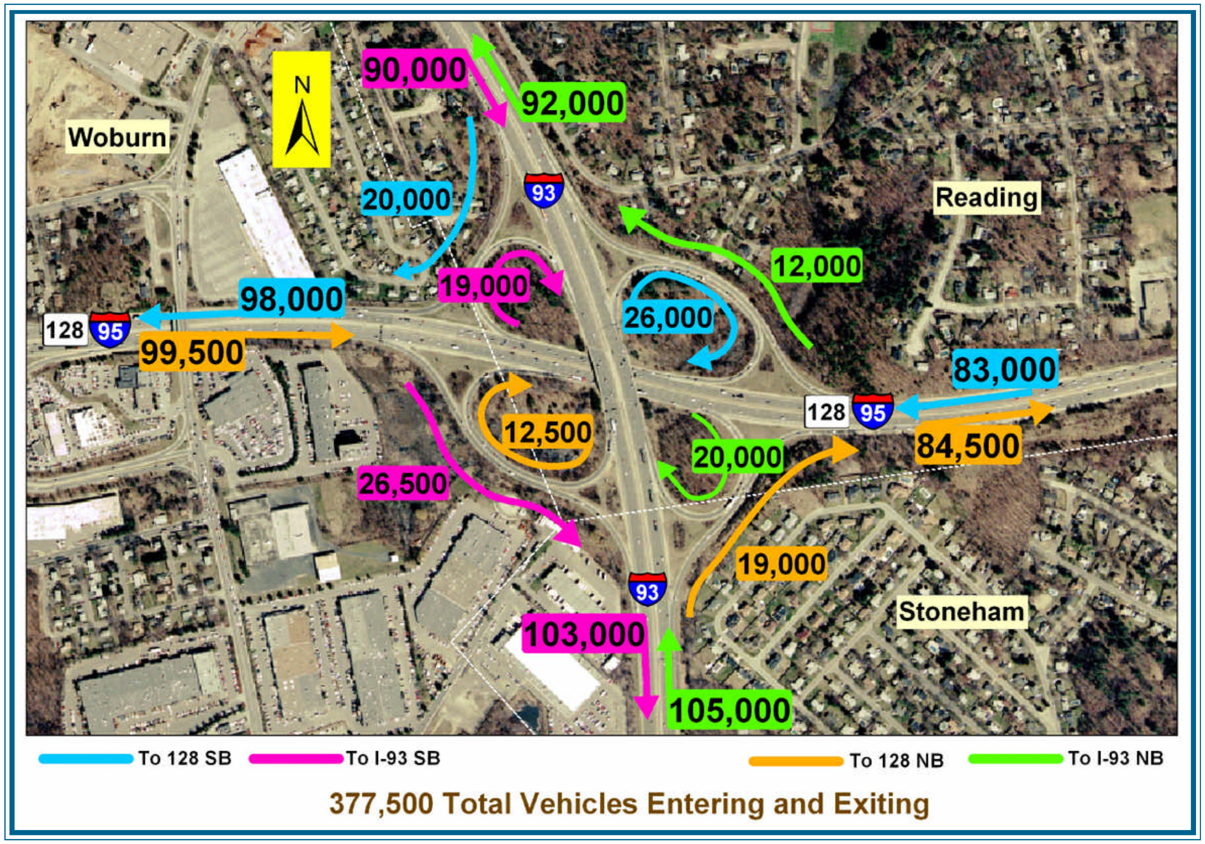
This chapter reviews the data and analyses used to develop an understanding of existing and potential future conditions in the I-93/I-95 local focus area and regional focus area, and to define the problems that need to be solved.

2.1 Traffic Volumes

The study area is located at the focus of I-95 (Route 128) and I-93. I-93 is the major interstate corridor linking Boston and Logan Airport with Massachusetts and New Hampshire cities and towns to the north. I-95 serves the north shore of Massachusetts, the New Hampshire seacoast, and Maine, and it forms much of the Route 128 beltway before heading southwest to Providence and major east coast cities. Route 128 is a major spine for the largest employment centers outside Boston. These include Waltham, Lexington, Burlington, and the major commercial area in Woburn adjacent to the I-93/I-95 Interchange. Route 128 also serves as a major route to Boston via I-93 for the northwest residential communities.

The result of this regional geography is that very large traffic volumes converge on the I-93/I-95 Interchange. In 2004 total estimated weekday traffic at the interchange exceeded 377,000 vehicles. This is the highest traffic volume for any interchange in Massachusetts and a very high volume for any system interchange. Figure 2-1 illustrates the interchange volumes.

Figure 2-1: 2004 Traffic Volumes at the I-93/I-95 Interchange.



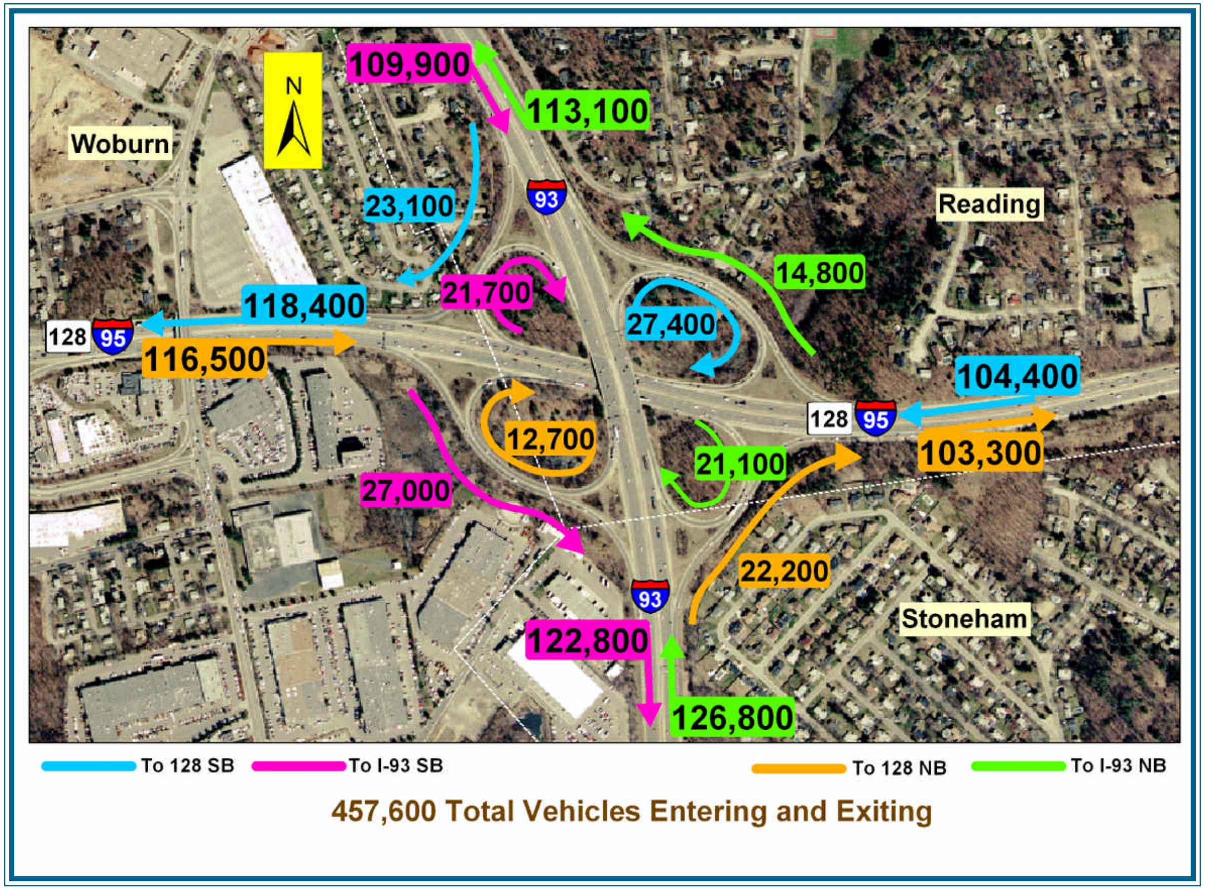
There are twelve possible paths through the interchange: two each on I-93 and Route 128 and eight moves between these highways on the interchange's four loop ramps and four slip ramps. As can be seen in the figure, the heaviest approach volumes are to and from the west on Route 128 and to and from the south on I-93. The heaviest ramp movements are on the southwest slip ramp (from Route 128 NB to I-93 SB) and the opposite movement on the northeast loop ramp. The lowest volumes are between Route 128 east of the interchange and I-93 north of the interchange via the northeast slip ramp and the southwest loop ramp. The southeast and northwest loops and slip ramps have volumes between the southwest and northeast ramps.

As large as these existing volumes are, future volumes are expected to be substantially larger. Future traffic is the result of a number of factors, including the number of vehicle trips per household, the mode split among single occupant vehicles (private automobiles with only one occupant), high occupant vehicles (e.g. carpools and van pools), transit (commuter rail, rapid transit, and bus). Pedestrians and bicycles are important locally but are negligible in regional-scale transportation.

The largest factor in determining future traffic volumes is future land use. Although the population of Massachusetts is relatively stable and even declined slightly in recent years, housing, shopping, and places of employment continue to be built in the region served by I-93 and Route 128, and these land use changes are expected to continue and to generate additional traffic volumes.

The Central Transportation Planning Staff (CTPS) maintains a regional travel demand model that includes a land use table which gives rise to person trips, a modal split to convert this demand to vehicle trips, and an assignment of the resulting vehicle trips to the roadway network. Based on the CTPS model, traffic volumes at the interchange are expected to increase approximately 21 percent between 2004 and 2025. The resulting volumes are shown in Figure 2-2.

Figure 2-2: 2025 No-Build Traffic Volumes at the I-93/I-95 Interchange.



2.1.1 A Note on Traffic Projections

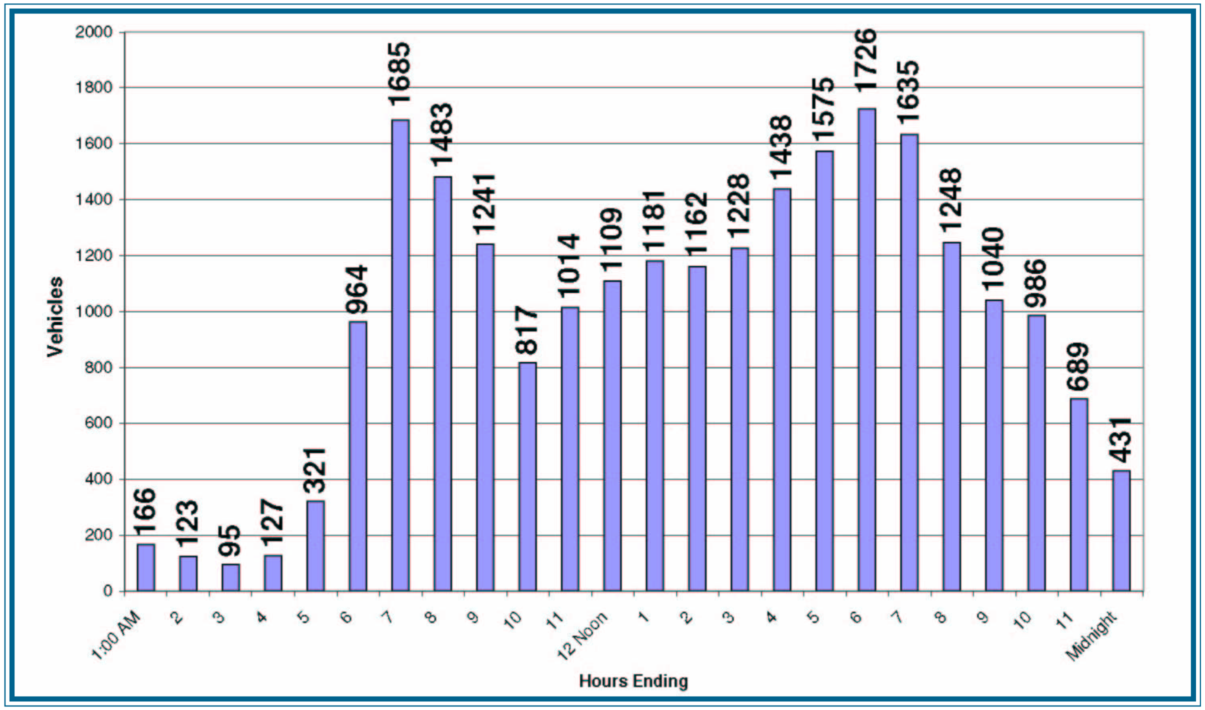
Travel demand is based on land use. Commercial and residential land uses generate trips at predictable rates, and the trips are distributed over the various modes of travel (for example, automobile or transit) in ways that reflect personal choices. The shares of trips by various transportation modes have shifted over the past twenty years, with the biggest increase in single occupant vehicles and decreases in the HOV and transit shares. Despite these changes, eastern Massachusetts still maintains one of the higher transit mode shares in the United States, owing to the extensive MBTA system of buses, rapid transit, and commuter rail.

The CTPS regional travel demand model is based on survey data on travel by mode, and the model's projections are based on detailed records and projections of land uses in the region, including planned future development and land availability. Although transit use and car pooling may well increase in response to fuel costs, there is no simple or standard way of projecting these changes. In this respect, the projections used in the I-93/I-95 Interchange Study can be considered worst case estimates. As will be discussed in the later chapters of this report, actions are recommended to improve transit and manage transportation demand, reducing the number of vehicles using the interchange so that the projected volumes would be reduced for the target year of 2025.

2.1.2 Daily and Hourly Traffic Volumes

That traffic volumes vary from hour-to-hour and from weekdays to Saturdays and Sundays is a familiar fact. Diagnosing the problems of the interchange depends on what these hourly volumes are. It is standard engineering practice to analyze the morning and afternoon peak hours because this is when traffic congestion is at its worst, and this pattern is typical of locations like the I-93/I-95 Interchange which carries large volumes of commuters on weekdays and a comparatively smaller proportion of non-commuter trips such as recreational travel. However, as Figure 2-3 shows, the peak periods at the interchange last more than one hour twice a day. This is due to both the regional nature of the interchange, which carries not only commuting trips but also trips for many purposes with a wide range of origins and destinations, and also to the fact that travel demand exceeds the capacity of the interstate highways in several parts of the regional focus area. When demand exceeds capacity, traffic becomes congested, travel times become longer, and many people divert either to earlier or later times or to bypass routes on local streets. This problem of "peak spreading" and diverting traffic will become greater as travel demand increases over the next twenty years.

Figure 2-3: Hourly Variation in Traffic, Route 128 NB to I-93 SB.



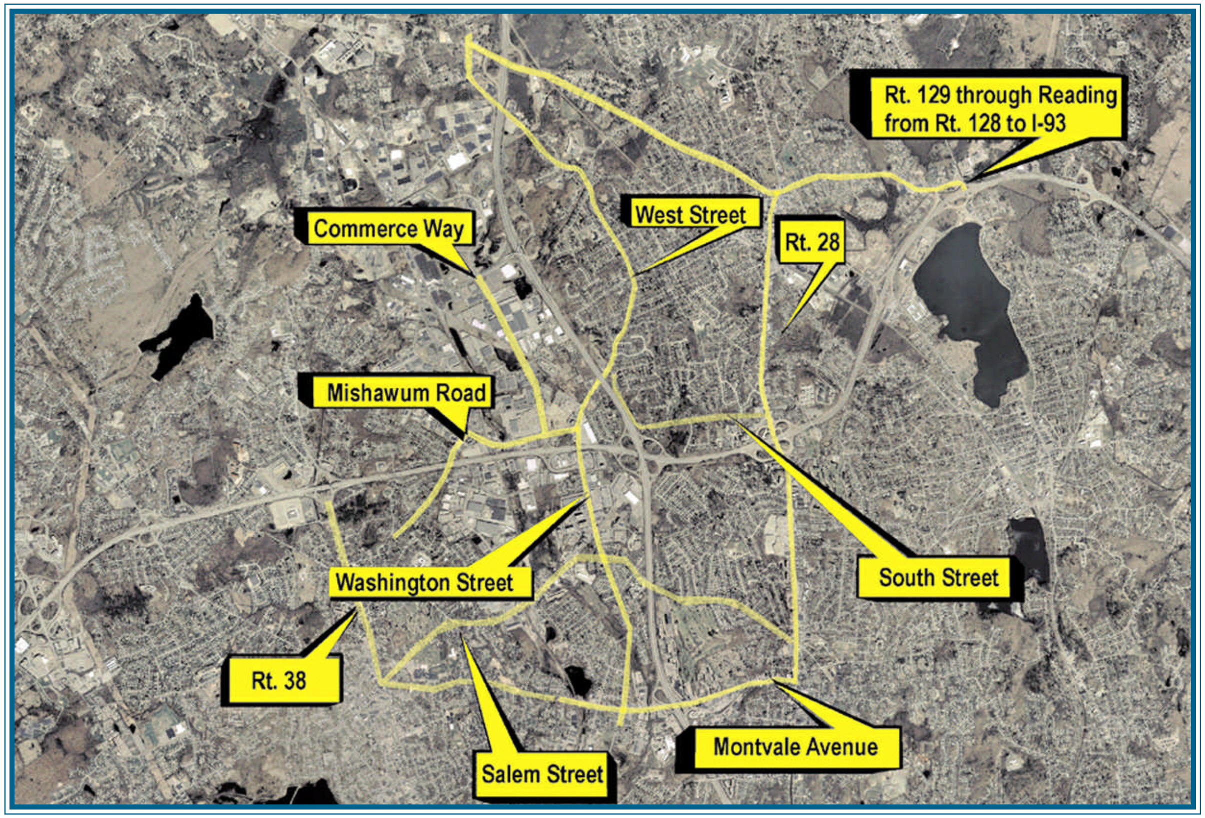
2.1.3 Local Streets and Intersections

Residents of Reading, Stoneham, and Woburn are familiar with the high traffic volumes that occur on arterial streets such as Route 28, Washington Street, and Montvale Avenue. These volumes result both from travel to land uses served by these streets as well as traffic diverted from the interstate highways owing to congestion. Figure 2-4 shows heavily traveled local roadways in the local focus area. An example is West Street which appears to carry traffic that leaves I-93 at Route 129 and uses West Street and Washington Street to reach destinations in the Woburn commercial area, rather than staying on I-93, passing through the interchange, and exiting to Mishawum Road.

Because of the relationship of traffic on these streets to the problems at the interchange, the local streets are part of the problem to be solved. To the extent that conditions at the interchange and the interstate highways can be improved, more traffic will be carried by those highways and some of the diverted traffic will return to I-93 and Route 128.

For these reasons, and because of their proximity to the central interchange, the local interchanges serving Route 28 in Reading/Stoneham and Mishawum Road and Washington Street in Woburn are part of the focus of the study.

Figure 2-4: Heavily Traveled Local Routes.



2.2 Interchange Geometrics

The I-93/I-95 Interchange was built in the early 1970s using then-prevalent design standards and serving substantially lower volumes. (Total weekday volumes in 1974 were 169,000 vehicles, or 45 percent of the 2004 volumes.) Figure 2-5 shows the portions of the interchange that are substandard in geometric dimensions such as ramp radius, length of weaving sections, and length of acceleration and deceleration lanes at on-ramps and off-ramps. These deficiencies have direct consequences for both congestion and safety. As the number of vehicles increases, merges and weaves become congested to a greater degree than would occur if dimensions were adequate, and conflicts between vehicles increase the rate of crashes. Substandard geometry also has consequences when the interchange is not busy: the I-93 SB ramp to Route 128 SB has been the location of truck roll-overs and the ramp has a warning sign about this hazard.

Figure 2-5: Areas of Substandard Geometry.

2.3 TRAFFIC OPERATIONS

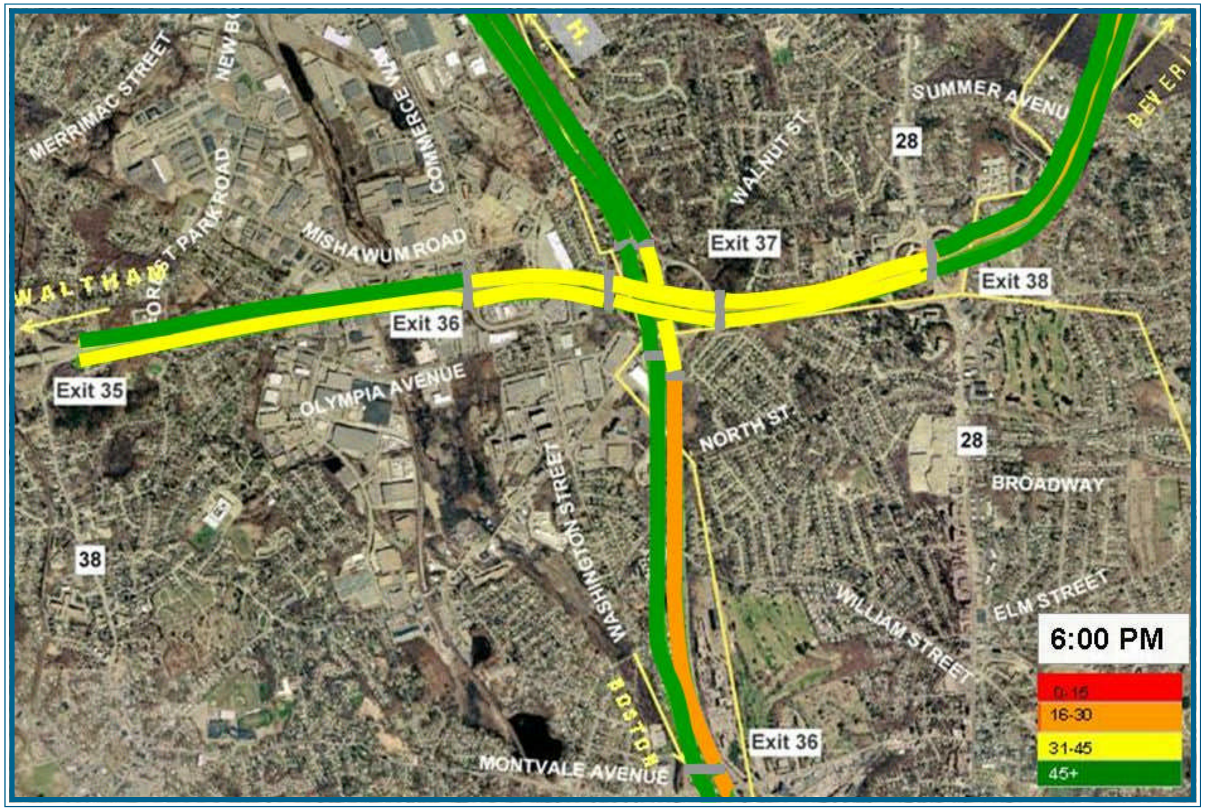
2.3.1 Congestion

Congestion can be observed in terms of the density of vehicles, reduced travel speeds, and the formation of backups (queues). Although people using the interchange are well aware of congestion, casual observation needs to be supplemented by analysis. In addition to counts of traffic volumes by MassHighway and the study team, CTPS conducted systematic travel speed observations in fall 2004 using cars with on-board global positioning systems to measure actual travel speeds. These speed data from 2004 provide a direct measurement of congestion and can be compared to 1999 speed data.

Travel Speeds

Figure 2-6 shows an example of travel speeds at the end of the afternoon peak hour. Although speeds decline as peak period congestion develops, the measured speeds are higher than commonly believed to be the case. However, speeds are much slower on days when factors like bad weather or incidents occur that temporarily restrict flow.

Figure 2-6: Travel Speeds in the Afternoon Peak Hour, 2004.

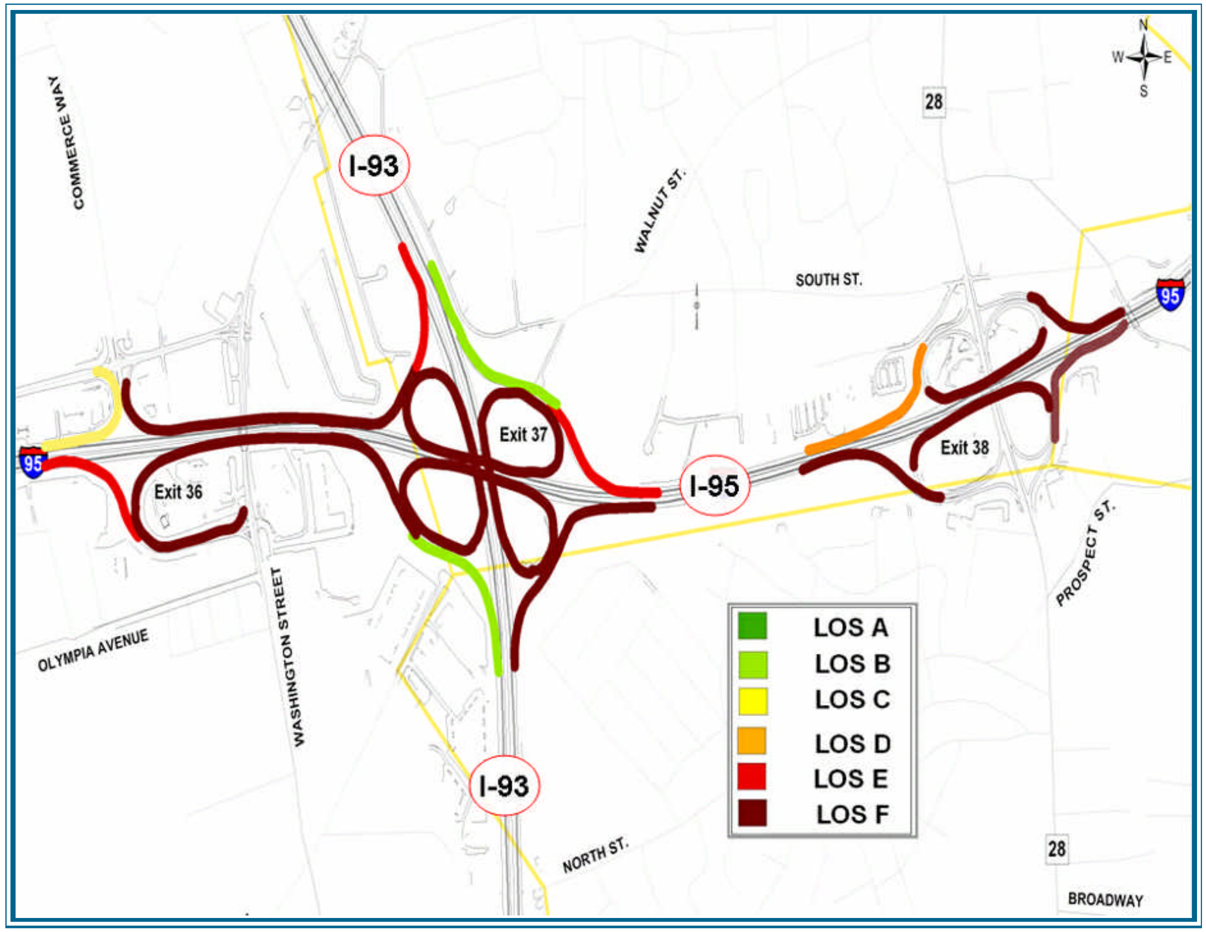


Levels of Service

In addition to travel speeds, two types of congestion analysis were performed. The first is "level of service" (LOS) analysis, a standard method used by traffic engineers to grade the traffic operations from LOS A (high speed, free flowing) to LOS F (stop-and-go). In general LOS A, B, and C are considered good levels of service by motorists. Level of service D is usually considered acceptable for urban conditions although speeds are reduced. LOS E is undesirable traffic flow approaching capacity, and LOS F describes breakdown of flow. These levels of service apply to normal dry-weather conditions; traffic flow becomes worse with rain or snow and can rapidly change for the worse if a lane is suddenly closed owing to an incident such as a crash or breakdown.

Figure 2-7 shows the projected 2025 levels of service for the major components of I-93/I-95 and the adjacent interchanges in the afternoon peak hour. This analysis was performed using standard HCS software based on the Highway Capacity Manual. Peak hour traffic volumes were obtained from the CTPS demand model results for 2025. The finding of this analysis is that major portions will operate at LOS F in both morning (not illustrated) and afternoon peak hours. These conditions are the result of high hourly traffic volumes on roadways and ramps with substandard weave, merge, and diverge distances.

Figure 2-7: Level of Service of Highway Elements, 2025 No-Build Afternoon Peak Hour.

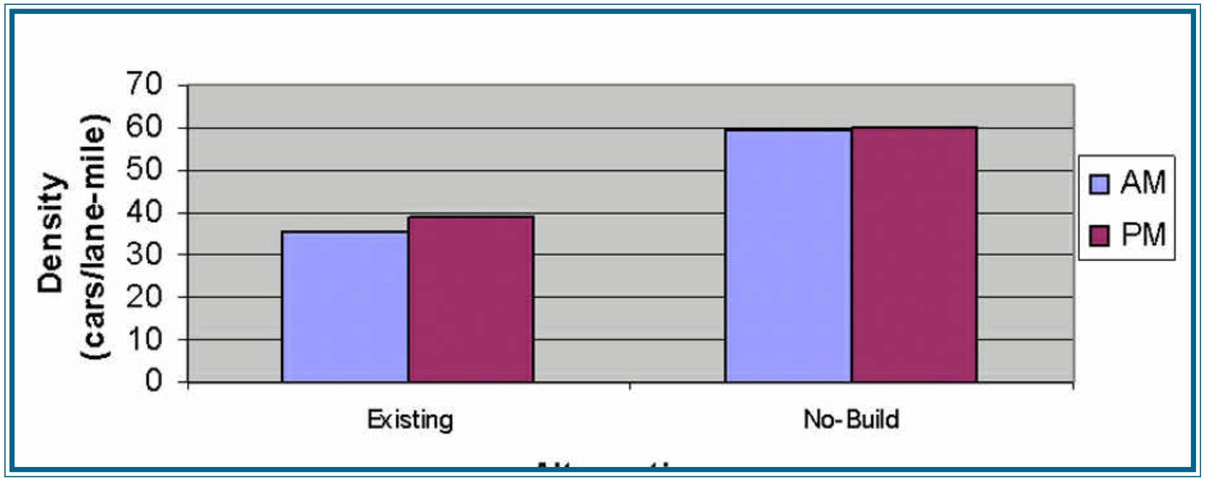


2.3.2 Microsimulation Analysis

In addition to the classical level of service analysis, a microsimulation model was developed, using CORSIM, a software package that creates a simulation of traffic flow by modeling driver behavior for each vehicle in the model. The modeled roadway network included I-93 and I-95 from south of the Route 38 interchange to north of the North Street interchange and from Montvale Avenue to Route 129 on I-93. The model also included Washington Street, Mishawum Road, Commerce Way, Route 28, and Montvale Avenue and the signalized intersections adjacent to the interchanges. Actual lane configurations and signal timing were incorporated in the model. CTPS speed data and 2004 traffic counts were used to calibrate the model, that is, the model output agreed with the actual data within an aggregate tolerance of 3 percent for the freeway links and 4 percent for the ramp links. The result is a simulation for the 7AM to 8AM hour and the 4PM to 5 PM hour. The model produces a range of statistics on the traffic flow (such as travel time, vehicle density, number of entering and exiting vehicles, travel speeds by lane, etc.) and an animation of the entire hour of each simulation.

The CORSIM results for the existing condition and 2025 No-Build provide a number of insights into traffic operations at the interchange. Figure 2-8 shows the density of traffic in 2004 and as projected for 2025 if no action is taken. Congestion, as measured by vehicles per lane per mile (vplpm) would increase from less than 40 vplpm to nearly 60 vplpm in both peak hours.

Figure 2-8: Modeled Traffic Density in AM and PM Peak Hour, Existing and 2025 No-Build.



Among the conclusions of the simulations is that the 2025 demand cannot be fully accommodated by the interstate highways and the interchange, Figure 2-9 shows the modeled existing and future number of vehicles "exiting" the modeled area: this is equivalent to the number of vehicles processed by the I-93/I-95 Interchange and adjacent interchanges and highway segments. In the morning weekday peak hour, the number of vehicles exiting the modeled area is currently less than 25,000; this would increase to slightly more than 27,000 with future growth. The afternoon peak hour is already at the modeled limit of nearly 27,000 vehicles. (Fewer vehicles can be accommodated with the afternoon traffic pattern.) This modeled output, which agrees well with existing traffic volumes, means that a portion of the 2025 traffic, approximately 20 percent, would divert to local streets or to earlier or later hours if the highways and interchanges are not modified.

Figure 2-9: Modeled Number of Exiting Vehicles in AM and PM Peak Hour, Existing and 2025 No-Build.

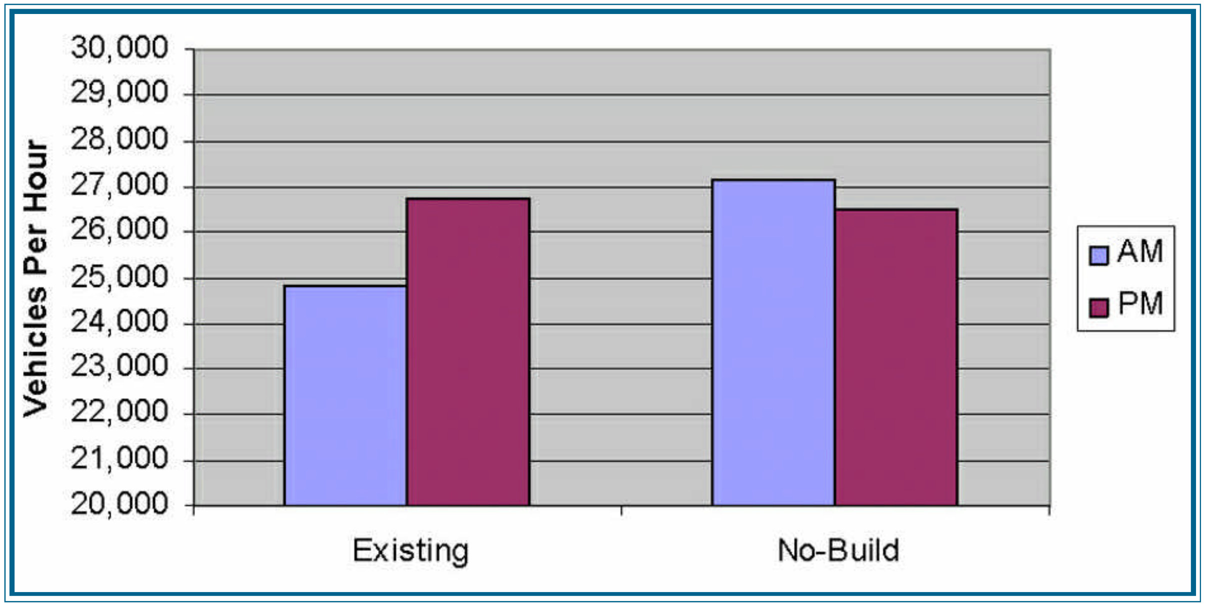
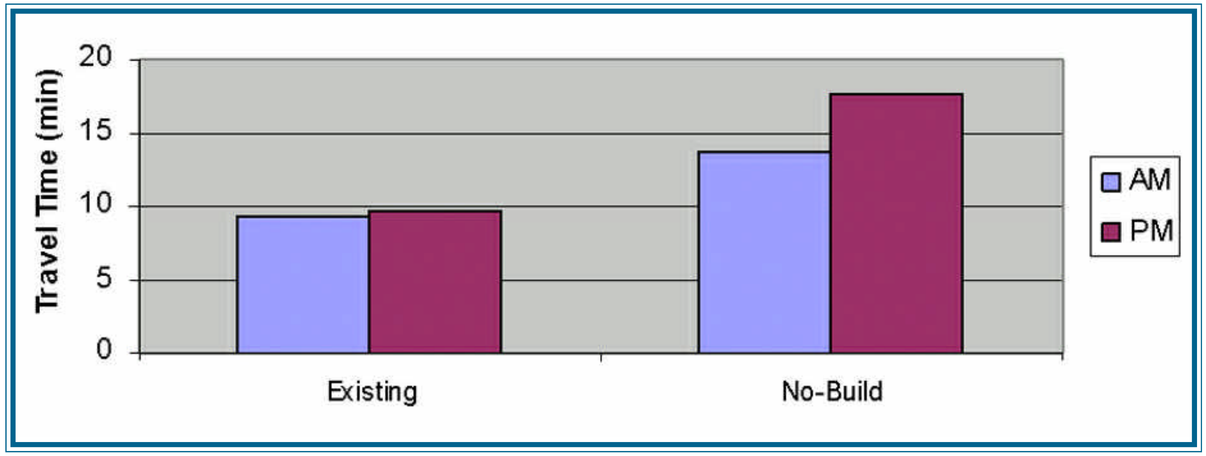


Figure 2-10 shows the modeled average travel time for all twelve paths through the interchange area. This time is currently less than 10 minutes on a normal day without delays due to incidents. In 2025 the time would expand to approximately 14 minutes in the morning peak hour and more than 17 minutes in the afternoon peak hour.

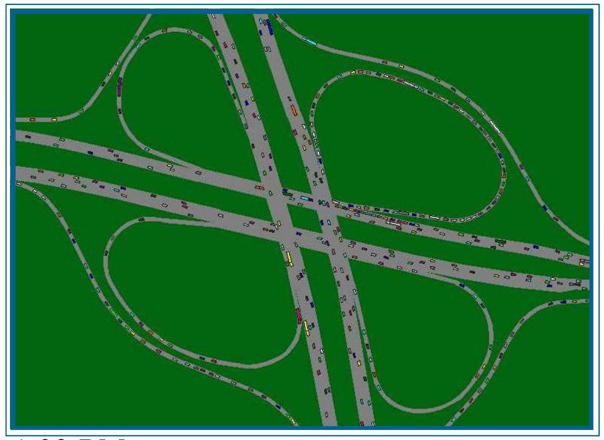
Figure 2-10: Modeled Average Travel Time in AM and PM Peak Hour, Existing and 2025 No-Build.



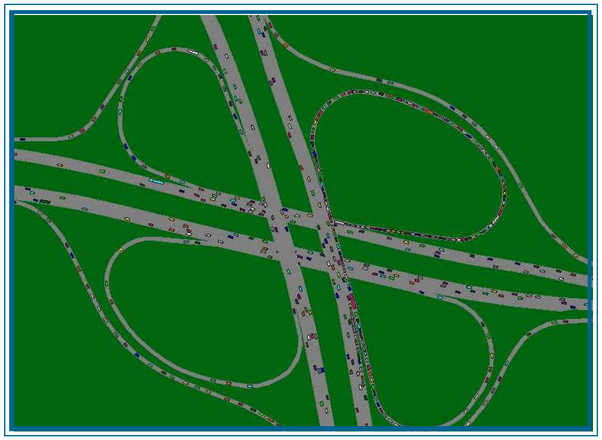
In addition to these statistical results, the microsimulations demonstrate a pattern of congestion that can be observed today. As shown in Figure 2-11 for the 2025 afternoon peak hour, major congestion in the interchange begins at the southbound weave on Route 128, where traffic entering Route 128 from I-93 northbound (a particularly heavy move in the morning peak period) must cross paths with traffic leaving Route 128 for I-93 SB at the adjacent loop ramp. The consequence of this congestion is that traffic backs up on the northeast loop ramp until the queue on I-93 blocks traffic leaving the southeast loop ramp, and this loop then backs up until its queue causes back-ups on the southwest loop ramp. This, in turn causes back-ups on Route 128 to the Washington Street on-ramp, and the adjacent slip ramps are also blocked. In summary, backups first appear at the Route 128 southbound weave and cascade around the interchange in a clockwise direction. For 2025, the interchange is fully gridlocked by 8:30 in the morning and 4:30 in the afternoon.

The CORSIM analysis also shows a second problem which can be observed today. Route 128 NB makes a transition from four lanes to three lanes just past I-93. This lane drop coincides with the weaving area between I-93 and the adjacent Route 28 interchange, and a back-up forms on Route 128 which extends back through the central interchange, delaying through traffic on Route 128 and exacerbating the interchange problems.

Figure 2-11: Simulation of Traffic, PM Peak Hour, 2025 No-Build.



4:09 PM



4:12 PM

4:15 PM

4:30 PM

These observations of geometric deficiencies, poor level of service, and traffic back-ups suggest that the Route 128 southbound weave and the 128 northbound lane drop are priority areas for improvement of traffic flow.

2.4 SAFETY

Note: Following Federal Highway Administration practices, this report uses the term "crash" in preference to "accident", because it is neutral as to cause and preventability.

2.4.1 Methodology and Data

Three methods were used to examine safety problems at the I-93/I-95 Interchange. Data are collected continuously from crash reports filed at the Registry of Motor Vehicles and processed in the Massachusetts Crash Data System (CDS). The crash reporting form was revised in late 2001 based on the recommendations of a study of the crash data system; the new reports, which are in use today, collect substantially more information on the causes of crashes and the conditions when they occurred. Owing to the large volume of data, annual statistics are not completed until well after the end of the reporting year. In addition, the change in crash reporting forms as well as variable conditions such as the occurrence of hazardous weather conditions in peak periods, means that year-to-year comparisons of the data are not reliable. However, the data from several years together provide very useful information about the pattern of crashes at the interchange.

Three types of analysis were used:

- **Number of crashes and severity:** This is the annual reporting that MassHighway prepares for the latest available year of data on the number of crashes and their severity.
- **Crash rate analysis:** Locations that have high traffic volumes will also have large numbers of crashes. Therefore, an analysis of the crash rate was prepared for I-93/I-95 and other major interchanges in Massachusetts by dividing the number of crashes by the traffic volume.
- **Crash cluster diagrams:** Individual crash reports were examined for the interchange area and for those reports that provided information locating the crash within the interchange, a diagram of crash locations was prepared, showing patterns of crashes.

2.4.2 Overall Incidence of Crashes

The I-93/I-95 Interchange is consistently one of the top ten locations in Massachusetts in number of crashes. The annual reports provide a weighted total that gives heavier weight to personal injury crashes and fatalities. During the period 1995 to 2001, the annual number of reported crashes at the I-93/I-95 Interchange ranged from 148 to 228. Figure 2-12 shows the ranking of locations with the largest incidence of crashes for those years. I-93/I-95 varies in rank but was no lower than sixth in the state for 1995 to 2001. Fatalities are relatively uncommon at the interchange, but the rate of personal injury crashes ranged from 26 to 42 percent for these years. Property damage crashes are significant both for their economic cost and also for the disruption to traffic flow which can result from even a relatively minor crash.

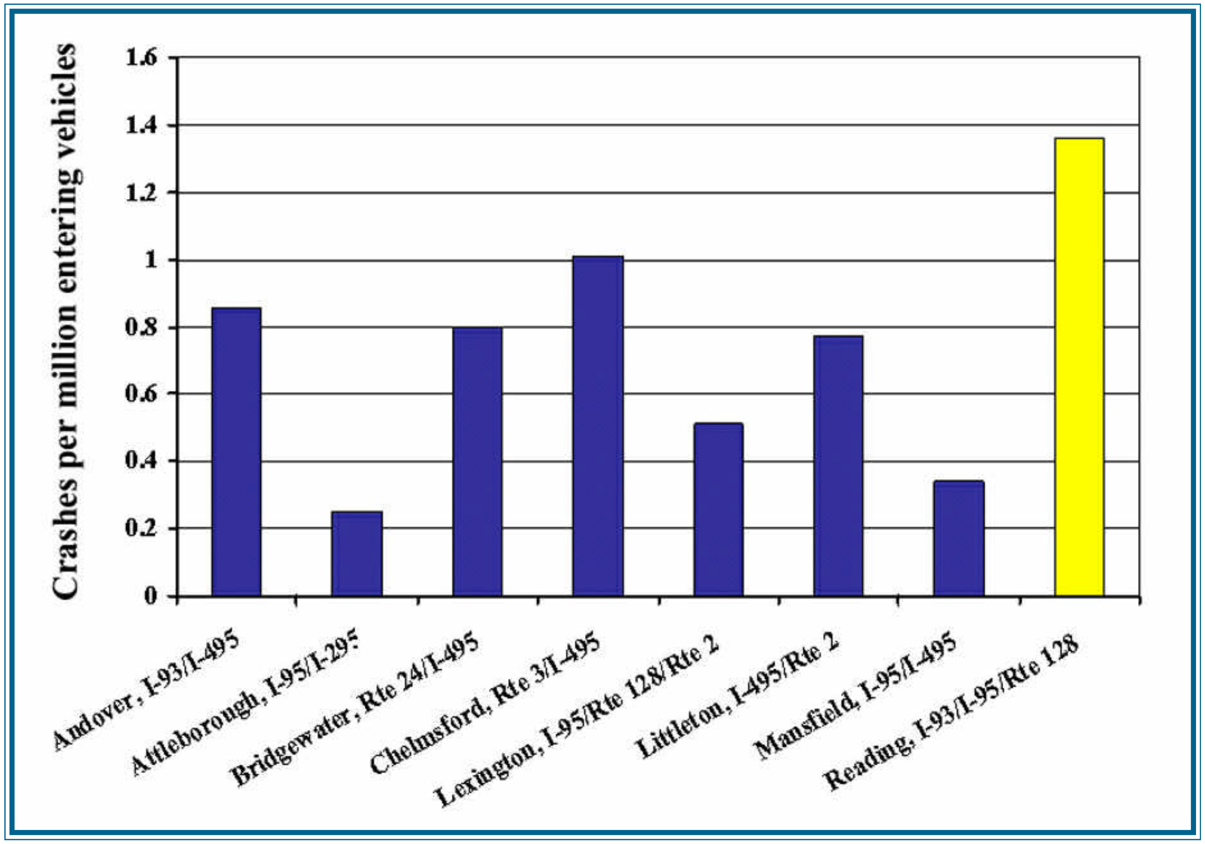
Figure 2-12: Ranking of Massachusetts Locations with the Highest Incidence of Crashes, 1996-2001.

RANK	1995	1996	1997	1998	1999	2000	2001
1	**I93/I95 Reading**	Leverett Circle	Copeland Circle	**I93/I95 Reading**	Kneeland/I-90	Mystic Av/I93	Mystic Av/I93
2	Copeland Circle Revere	Mystic Av/I93	**I93/I95 Reading**	Copeland Circle	**I93/I95 Reading**	Drum Hill Rotary	Copeland Circle
3	Mystic Av/I93	Dewey Sq Tunnel	Drum Hill Rotary	Mystic Av/I93	Drum Hill Rotary	Leverett Circle	Drum Hill Rotary
4	Drum Hill Rotary	**I93/I95 Reading**	Mystic Av/I93	Rte 1/Walnut St	Copeland Circle	I-90/I-95 Weston	**I93/I95 Reading**
5	Leverett Circle	Bell Circle	Leverett Circle	I-95/Rte 3 Burlington	Mystic Av/I93	Copeland Circle	Rt 16/Fellsway
6	Bell Circle Revere	Copeland Circle	Rte 1/Rte 114 Danvers	I-93/Columbia Rd	Leverett Circle	**I93/I95 Reading**	Leverett Circle
7	Rte 1/Rte 114 Danvers	Drum Hill Rotary	Rte 1/Walnut St	Mass Av/Melnea Cass Boston	Mass Av/Melnea Cass Boston	Rt 16/Fellsway Medford	I-95/Rte 3 Burlington
8	Rte 1/Walnut St	Rt 16/I-93 Medford	Rt 16/Fellsway Medford	Drum Hill Rotary	Frontage/South-hampton Boston	Kneeland/I-90 Boston	I-93/Mass Ave
9	Dewey Sq Tunnel	Rt 16/Fellsway Medford	I-95 Canton	Airport Rd, Logan	Rte 1/Walnut St	I-95/Rte 3 Burlington	I-95/Winter St
10	Storrow/ Charlesgate	I-93/Rte 38 Woburn	I-93/Granite St Braintree	I-93/Rt 110 Methuen	I-95/Winter St	Rte 1/Walnut St	I-93/Montvale

2.4.3 Crash Rate

Figure 2-13 shows the rate of crashes for I-93/I-95 and several other major Massachusetts interchanges with high crash incidence. Although the rate varies for the two periods analyzed, I-93/I-95 has a substantially higher crash rate per million entering vehicles than any other cloverleaf interchange and is comparable only to the Weston toll plaza on the Massachusetts Turnpike.

Figure 2-13: Crash Rate for I-93/I-95 and Other Major Massachusetts Interchanges, 1999 -2001.



2.4.4 Crash Clusters

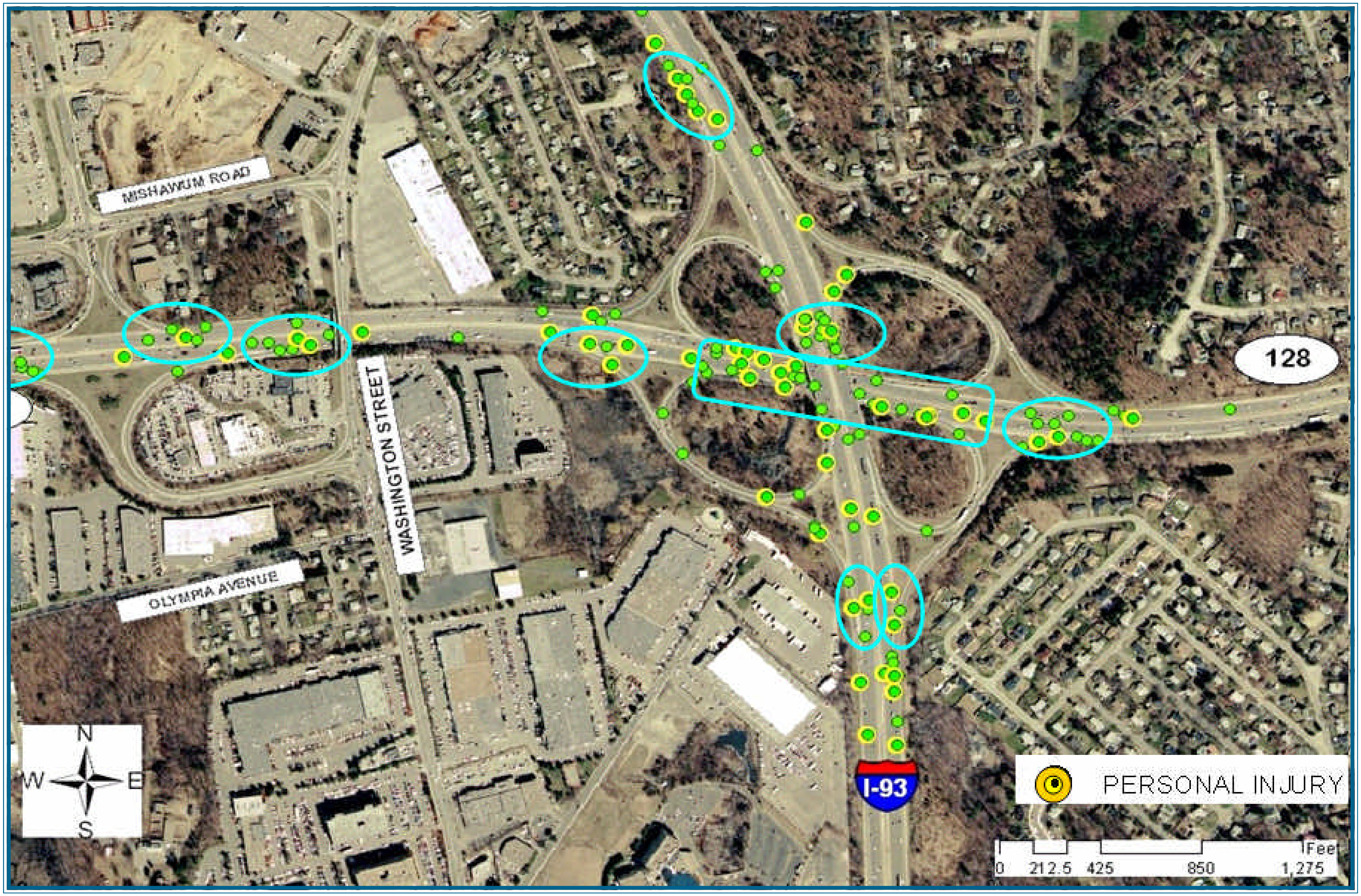
Using the individual crash reports to localize crashes that occurred in the interchange, diagrams were prepared for 2002, 2003, and 2004. The 2003 diagram shown in Figure 2-14 is representative of all three years. As can be seen in the diagram, there is a noticeable clustering of crashes in the locations where conflicting traffic moves occur: weaves, where traffic patterns must cross; merges where traffic must accelerate to match speed with traffic on the highway; and diverges,, where traffic slows to exit the highway. Existing lines of sight also seem to have an effect on crash clusters; for example sight lines are poor on Route 128 NB approaching the off ramp to I-93 SB and a cluster of crashes occurs at this diverge point; I-93 NB, on the other hand has relatively good sight lines to the interchange, and there are fewer crashes associated with the weave in this area than on Route 128 under the I-93 bridge.

Table 2-1 compiles the location data on crashes for 2002, 2003, and 2004, and it shows the percentage of crashes associated with each conflict area.

Table 2-1: Percentage of Crashes Associated with Interchange Conflict Areas.

	Existing Locations		**2002**	**%**	**2003**	**%**	**2004**	**%**	**Average Number of Crashes**
I-95 NB	Washington Street Diverge		12	8%	10	7%	3	3%	8
	Washington Street Merge	Weave	9	6%	10	7%	8	8%	9
	Diverge to I-93 SB		16	11%	4	3%	7	7%	9
	I-93 SB Merge	Weave							
	I-93 NB Diverge		14	10%	23	16%	19	19%	19
	I-93 NB Merge		9	6%	10	7%	2	2%	7
	Loop Ramp from 93SB		1	1%	4	3%	5	5%	3
I-95 SB	I-93 NB Diverge		2	1%	4	3%	6	6%	4
	I-93 NB Merge	Weave							
	I-93 SB Diverge		10	7%	10	7%	12	12%	11
	I-93 SB Merge		10	7%	4	3%	2	2%	5
	Washington Street Diverge		11	8%	6	4%	6	6%	8
	Washington Street Merge		12	8%	3	2%	1	1%	5
	Loop Ramp from 93NB		0	0%	2	1%	2	2%	1
I-93 NB	I-95NB Diverge		6	4%	8	5%	2	2%	5
	I-95NB Merge	Weave							
	I-95 SB Diverge		7	5%	12	8%	10	10%	10
	I-95 SB Merge		4	3%	3	2%	1	1%	3
	Loop Ramp from 95NB		0	0%	1	1%	0	0%	0
	Slip Ramp from 95SB		0	0%	1	1%	0	0%	0
I-93 SB	I-95SB Diverge		2	1%	8	5%	0	0%	3
	I-95SB Merge	Weave							
	I-95 NB Diverge		10	7%	13	9%	7	7%	10
	I-95 NB Merge		5	17%	8	28%	3	10%	5
	Slip Ramp from 95NB		2	1%	2	1%	2	2%	2
	Total Crashes (Average of 2002-2004)		**142**		**146**		**98**		**127**

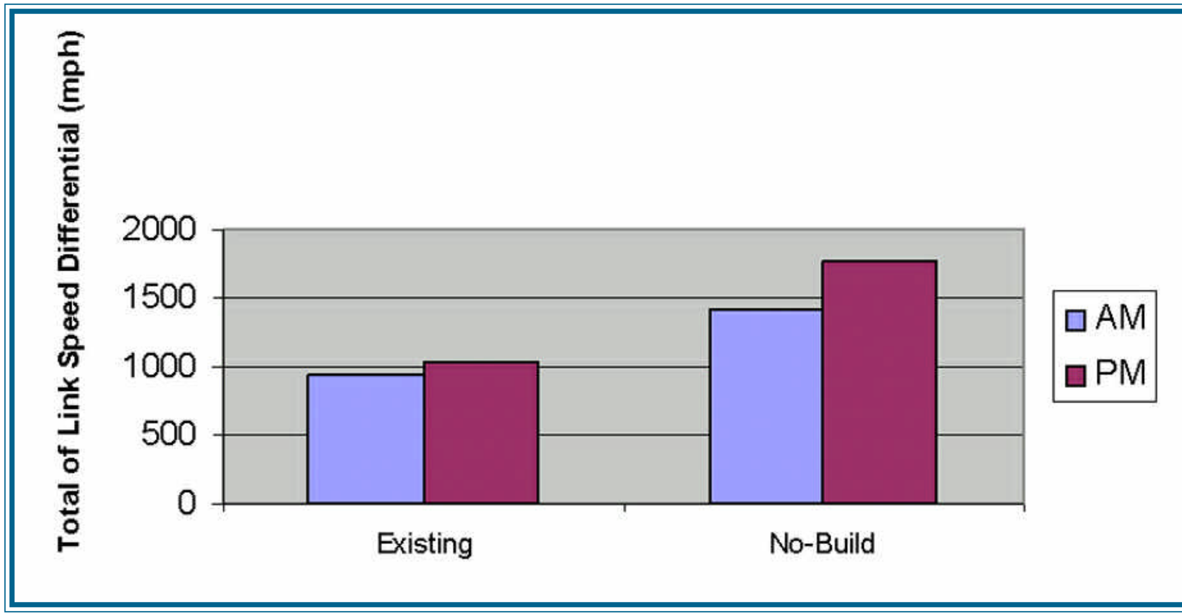
Figure 2-14: Crash Pattern for 2003.



2.4.5 Speed Differentials

Figure 2-15 shows existing and future total speed differentials for the interchange areas. These statistics are the sum of the difference between modeled speeds in the fastest and slowest moving lane for each of the 103 highway segments in the CORSIM model. Higher speed differentials have the potential to increase the number and severity of crashes.

Figure 2-15: Total Speed Differential for AM and PM Peak Hour, 2004 and 2025.



2.4.6 Safety Predictions

There was discussion in the Interchange Task Force on whether the number of crashes could be predicted for various alternatives for improving the interchange. Unfortunately, the complexity of the I-93/I-95 Interchange goes beyond the current state of engineering techniques to make crash predictions. There is a great deal of knowledge about "crash reduction factors" for relatively simple rural highway situations, and the Federal Highway Administration is sponsoring the development of a "Safety Analyst" model to make crash predictions for these simpler situations, but no techniques are forthcoming for major interstate highway interchanges.

Therefore, the alternatives developed for the I-93/I-95 Interchange were evaluated in terms of the percentages of crashes addressed by either improving or eliminating conflict areas, as displayed in Table 2-1. This analysis is presented in Chapter 3.

2.5 Public Transportation

An objective of the I-93/I-95 Interchange Transportation Study is to improve mobility, for people's transportation needs in the study area. Mobility includes improving travel time and reliability for motorists, as well as providing convenient and effective choices of other modes of travel. Public transportation options increase mobility by providing choices and also by reducing the number of vehicles on the roadways.

There are currently a number of public transportation services in the study area that serve travel in the I-93 corridor to Boston. Available services along the Route 128 corridor are much more limited, one recent example being a demonstration shuttle service operated by the 128 Business Council in 2005 and 2006.

Among the available transit services are the following:

- MBTA commuter rail service on the Lowell and Haverhill Lines with stops at the Anderson Transportation Center and Mishawum Station in Woburn and Reading Center, respectively.
- MBTA rapid transit service on the Orange Line from Oak Grove in Malden
- MBTA bus routes 136/137, 132, and 354 serving Stoneham, Reading, and Woburn to Boston
- Massport Logan Express from Woburn (Anderson RTC)
- MVRTA commuter bus from Haverhill to Boston

The Anderson Regional Transportation Center (ARTC) is a major study area resource. It has a large parking lot in which only approximately 400 of the 1500 parking spaces are used, an enclosed passenger station, and facilities for bus transfer, passenger drop-off, and short-term parking. Boardings at the station are currently approximately 800 per day. ARTC has the potential to serve many more commuter rail passengers and to serve as a hub for shuttle service to the immediate Woburn business area and potentially longer distance shuttles along the Route 128 corridor.

Anderson Regional Transportation Center.

Reading Center on the Haverhill Line has approximately 700 daily boardings but the limited parking at the station is fully used.

Pedestrian and bicycle access are important locally and have the potential to serve as a connection between the ARTC and residences and businesses.

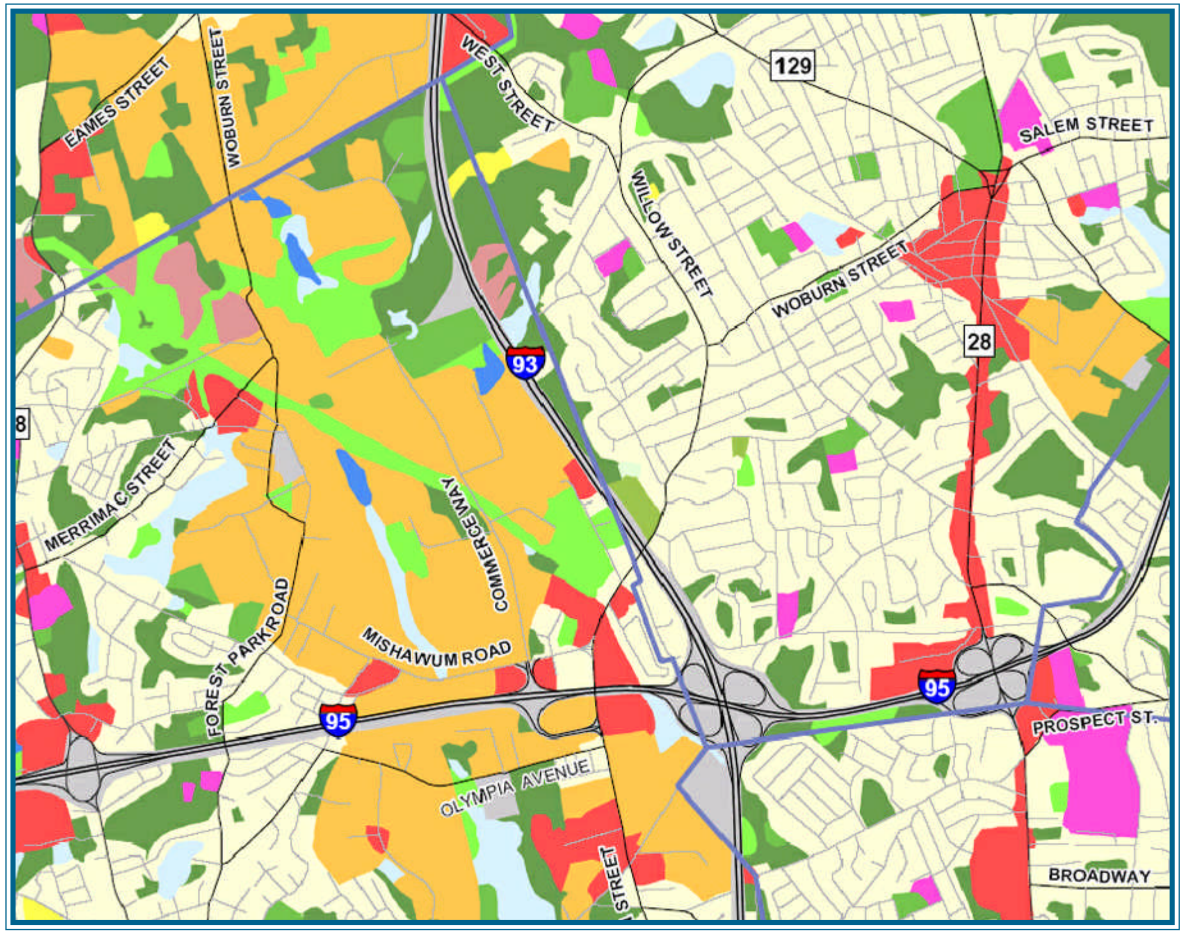
2.6 CONTEXT

Context refers to the pattern of land uses, communities, and natural resources that surround the highways and are both served and affected by those highways. Good engineering practice can recognize the importance of quality of life in communities by meeting transportation design criteria without undue impacts to surrounding neighborhoods and natural resources. This is consistent with "Context Sensitive Design" practices which are becoming the standard for engineering and have become a central part of the MassHighway 2006 Project Development and Design Guide.

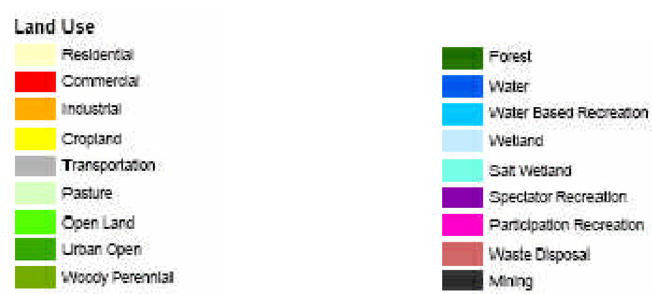
2.6.1 Land Use and Communities

Figure 2-16 shows the land uses that closely surround the interchange. The towns of Reading and Stoneham and the City of Woburn meet at a point in the southwest quadrant of the interchange.

Figure 2-16: Land Uses Near the I-93/I-95 Interchange.



Source: Mass GIS



Residential Communities

In the northwest quadrant of the interchange, single-family residences are adjacent to the highway right of way on Richard Circle, Woburn, and Border Road, Reading. In the northeast, there are single-family residences and some condominiums on Walnut Street, South Street, Heather Road, George Street, and Curtis Street that abut or are near the highways, and many other residences close enough for highway noise to be audible; the residential neighborhoods in Reading near Route 128 continue almost to North Avenue/John Street. In the southeast, single family residences on Constitution Road, Crosby Street and Evergreen, Pine Ridge, and Drummond Streets and Paula and Moulton Avenues abut or lie near the interchange and Route 128, and large residential neighborhoods lie immediately south of Route 128 in Stoneham and Wakefield.

The possibility of residential takings has been a major concern for these neighborhoods in the past. Noise, visual, and air quality impacts from the existing highways and potential highway improvements have also been important neighborhood concerns. In addition, traffic diverting from the interstate highways is a source of impacts to residential areas in all three communities. Access for residents and for emergency vehicles must be maintained.

Within the predominantly business area in Woburn there are a residential neighborhood at the corner of Olympia Avenue and Washington Street, apartments on Cedar Street, and residences on Mishawum Road near Commerce Way. Large residential neighborhoods extend to Route 128 between the commercial area and Route 38. These residential enclaves are sensitive to highway noise and air pollution and are also directly affected by traffic on local roadways. For example, cut-through traffic has been a problem for the neighborhood at Olympia Avenue and Washington Street.

Business Districts

In the southwest, a number of businesses abut the interchange. These are part of the large area of Woburn businesses including offices, retail, warehouse, and light industrial use that extends along Washington Street, Olympia Avenue, Mishawum Road, Commerce Way, New Boston Street and other streets both north and south of Route 128. These businesses depend on access from Route 128 and I-93 via the Mishawum Road on- and off- ramps on the southbound side of Route 128 and via the Washington Street on- and off-ramps on the northbound side.

The Woburn business area is a thriving area that has seen transition over the years from a rail-oriented industrial area to an emerging area of both start-up and established businesses. Improvements have been made by the city on major streets such as Commerce Way, and the development of the former Industriplex site into new office and retail uses has followed the construction of Exit 37C on I-93 and the relocation of most MBTA commuter rail service from Mishawum Station to the Anderson Regional Transportation Center. Retail development has occurred near the Route 128 access ramps including the recent construction of a Lowes home improvement store and improvements to the Woburn Mall. A major retail development has been proposed for the former W. R. Grace site on Washington Street south of Route 128. The potential for redevelopment of commercial land to higher value uses clearly exists, particularly near the Route 128 access ramps. The state-owned land at Mishawum Station has been under discussion by the city for transit-oriented or other development, and the city has requested that this land not be considered a site for highway improvements.

Route 28 in Reading and Stoneham has several business districts between Reading Center and Stoneham Center. The former Addison-Wesley publishing company site at the corner of Route 28 and South Street abuts the Route 128 right of way; development proposals for this site have been under discussion with the Reading Planning and Development Commission. Commercial and retail uses also lie along Montvale Avenue in Stoneham and Woburn.

2.6.2 Natural Systems and Other Resources

Figure 2-17 shows natural resources in the local focus area, and Figure 2-18 shows a close-up of wetland areas in the immediate area of the interchange. Bordering vegetated wetlands occur within the southwest and northeast loop ramps, and wetlands lie immediately along southwest slip ramp in Woburn and northeast of the interchange in Reading. A series of wetlands runs to the south from just east of the MBTA commuter rail tracks near Route 128. These wetlands are protected resources under both the

Massachusetts Wetlands Protection Act and the federal Clean Water Act. Impacts on them should be avoided or minimized, and wetland replacement and mitigation is necessary to address any impacts that do occur. State-designated priority habitats for protected species and estimated habitats for rare wildlife do not occur near the interchange. Large bordering vegetated wetlands occur on both sides of Route 128 near North Avenue/John Street, and Lake Quinnapowitt in Wakefield is just south of Route 128.

No historic resources lie close to the I-93/I-95 interchange, although parts of South Street and Walnut Street in Reading are designated Scenic Roadways.

Certified Vernal Pools *
Potential Vernal Pools
DEP Zone II
Estimated Habitats for Rare Wildlife **
Priority Habitats *^

MassGIS 1:5000 Wetland Codes
OPEN WATER
SHALLOW MARSH MEADOW OR FEN
SHRUB SWAMP
WOODED SWAMP DECIDUOUS
WOODED SWAMP MIXED TREES

* *NHESP 2003 Massachusetts Certified Vernal Pools*

** *NHESP 2003 Estimated Habitats for Rare Wildlife: For Use with the MA Wetlands Protection Act Regulations (310 CMR 10)*

*^ *NHESP 2003 Priority Habitats for State-Protected Rare Species*

Source: MassGIS, 2003

Figure 2-17: Natural Resources Near the I-93/I-95 Interchange.

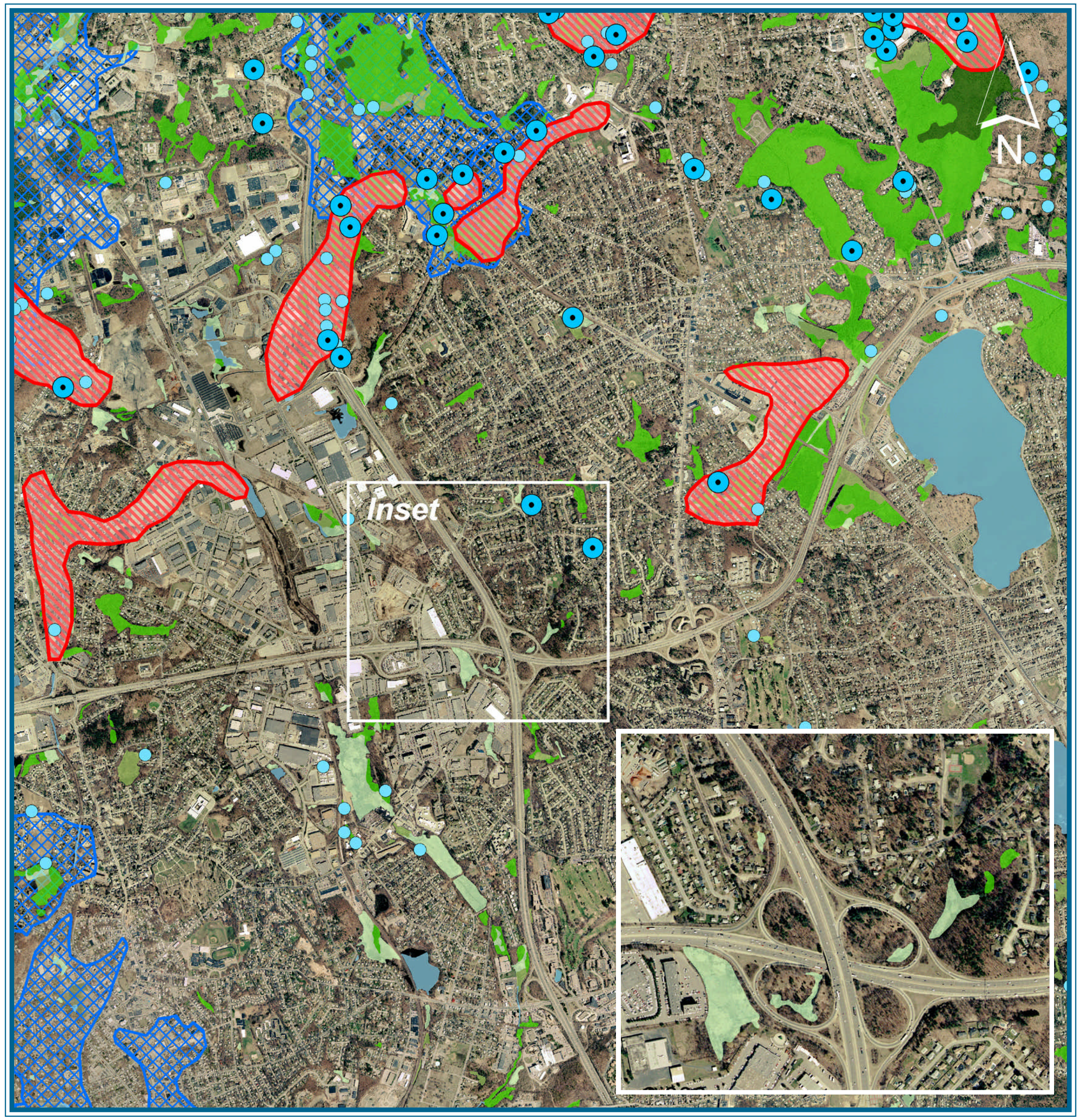
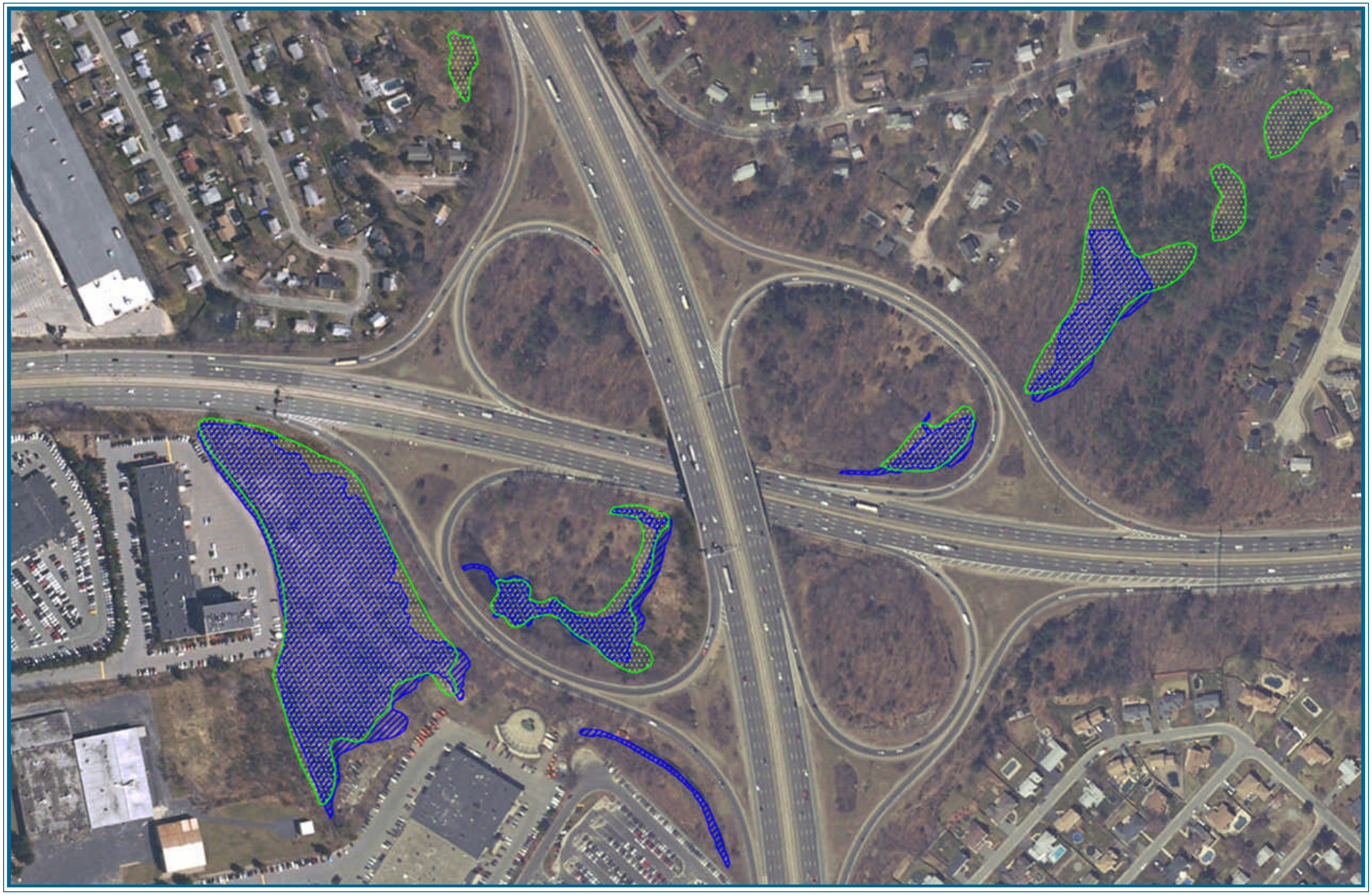


Figure 2-18: Wetlands at the I-93/I-95 Interchange. Note: Blue hatched areas are based on topographic survey; green outlines are from MassGIS data.

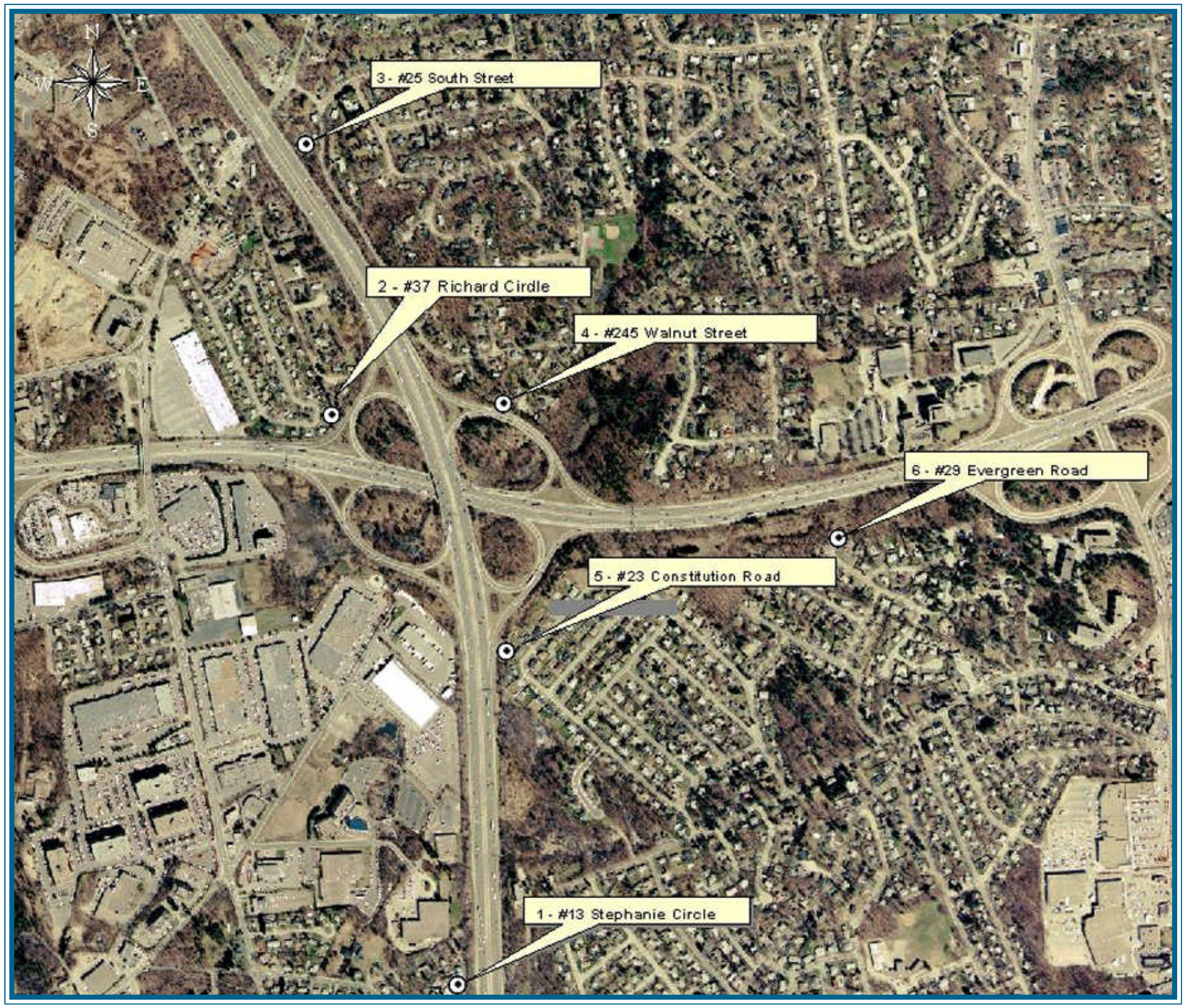


2.6.3 Noise

Noise is a concern for people living close to highways, and the Interchange Task Force considers it second only to takings. Federal Highway Administration and MassHighway have established Noise Abatement Criteria (NAC) for several types of noise-sensitive land uses. For residences the NAC is 67 dBA and the regulations provide for noise mitigation when highway noise levels approach this criterion, i.e., at 66 dBA or when new or reconstructed highways raise the existing noise levels by 10 dBA or more. In these cases, noise barriers are evaluated for community acceptability and effectiveness. Computer modeling in the environmental study of highway improvements is used to predict noise levels after construction and to evaluate noise barriers.

Twenty-four hour noise measurements were made in December 2004 to establish the severity of existing highway noise and provide a context for evaluating alternatives in Chapter 4. The six noise monitoring locations are shown in Figure 2-19. Figure 2-20 shows an example of the monitored noise levels; results for all six locations are located in Appendix C. In general, five of the six locations already experience noise levels high enough for noise mitigation to be considered. (The sixth monitoring location, on Evergreen Road in Stoneham, was more distant from the highway than the other locations.) Future noise levels are expected to increase from these measured levels as traffic volumes increase.

Figure 2-19: Noise Monitoring Locations.

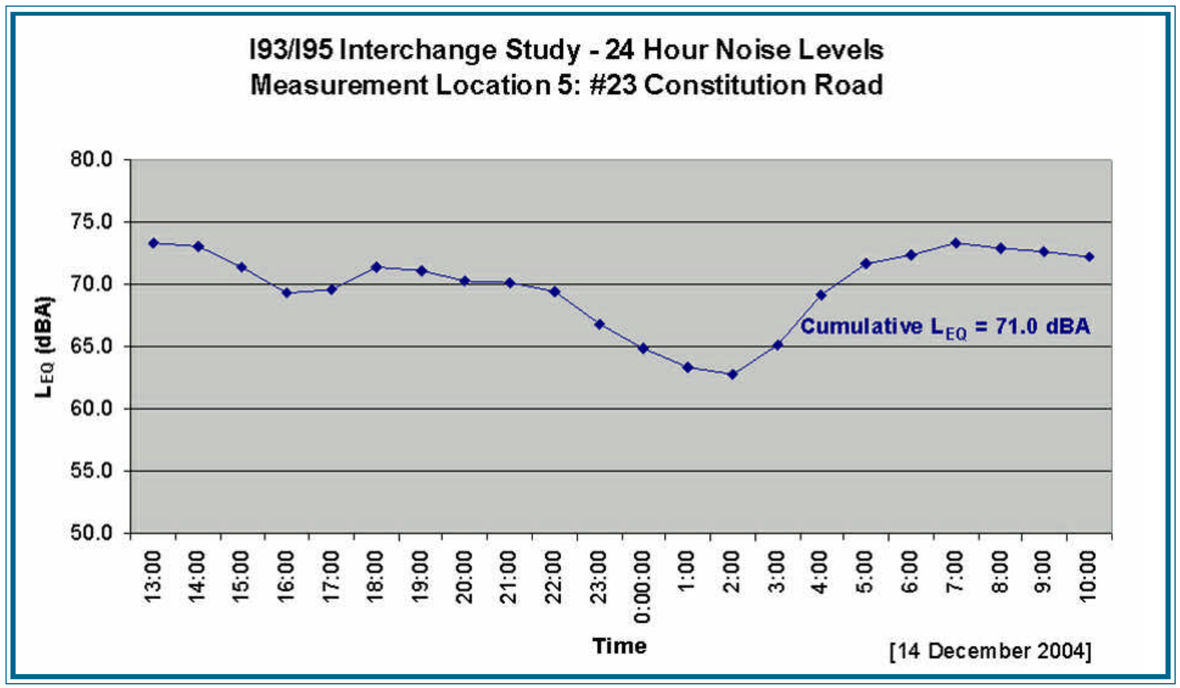


In addition to "Type I" noise mitigation which applies to new or reconstructed highways, a "Type II" program provides for mitigation of existing conditions that exceed the Noise Abatement Criteria. A number of locations near the I-93/I-95 Interchange were qualified for Type II mitigation, but there are many such locations on the list, and MassHighway has funding to provide barriers at only two locations in most years, so Type II mitigation is not expected to occur in the study area in the near future. Type I mitigation, on the other hand would be part of any major improvements of the interchange. In addition to noise barriers, measures such as pavements designed to reduce tire noise and designs that avoid steep grades can help to minimize highway noise impacts.

A Primer on Noise

- Noise is measured in decibels, a logarithmic scale. A standard unit of measure which integrates noise at a wide range of frequencies is "dBA".
- Most people can perceive 3 dBA differences in noise; 5 dBA is very noticeable; 1-2 dBA may not be perceptible.
- FHWA defines noise impact at residential property as 67 dBA.
- Noise levels decrease rapidly with distance.
- Highway noise is a function of several factors, including traffic volumes, percentage of trucks, pavement, and highway geometry, especially uphill and downhill grades.
- Computer models calibrated to actual noise levels can predict future noise based on highway designs and traffic volumes.
- Noise mitigation can be provided by solid, continuous barriers/berms that are high enough to deflect most highway noise. FHWA has standard procedures for determining the effectiveness of noise barriers.

Figure 2-20: Example of Hourly Noise Monitoring Results, 1PM to 11AM.



2.7 Problem Definition

The problems that need to be addressed at the I-93/I-95 Interchange can be summarized as follows:

Congestion

High traffic volumes and substandard roadway geometry result in poor levels of service and substantial congestion in peak travel periods. As a consequence, speeds are reduced, travel though the study area is delayed, and some traffic diverts to local streets to bypass the interchange area. Because of land use growth which is expected to occur over the next 20 years, the already high traffic volumes will increase substantially, with demand growing more than 20 percent on the interstate highways and 30 percent or more on the heavily traveled local routes.

The principal cause of backups in the interchange area is weaving traffic within the interchange and between it and the adjacent interchanges at Route 28 and Washington St/Mishawum Road. Both observed and modeled traffic congestion begins at the Route 128 southbound weave under I-93 and cascades around the interchange until gridlock occurs. This situation will become worse with the projected traffic growth. An additional problem is the lane drop from four lanes to three on Route 128 northbound just past I-93, causing backups through the interchange area.

Analysis and modeling of Route 128 traffic suggests that traffic will continue to be close to highway capacity in the future, with excess demand diverting or traveling earlier or later to avoid the peak periods. With volumes close to capacity, crashes and breakdowns cause major backups and delays. However, Route 128 does process the large volumes of traffic at reduced speed, and the problem in the study area is not the consequence of traffic backing up from downstream but rather is one of a series of congested areas which has particular importance because it affects traffic to and from I-93 as well. Any improvement in the interchange area will benefit travel on both highways and not be negated by downstream congestion on Route 128. In effect, every segment of Route 128 is a separate problem area, and improvement of the interchange area will benefit the portion of each trip that includes that section.

Safety

The I-93/I-95 Interchange has one of the highest crash totals in the state on a consistent basis, and controlling for traffic volumes it has the highest crash rate of any similar interchange in the state. Major causes of crashes are the congested weaving sections and substandard acceleration and deceleration lanes at merge and diverge points. Crash clusters occur at these conflict points, particularly where visibility is limited. The key to improving safety at the interchange is to bring as many of these conflict areas up to current geometric standards. Weaves are major conflict points that could be eliminated in some alternatives. Speed differentials between fast and slow lanes increase hazards and may also be improved by modifying the interchange.

Context Sensitive Design

Part of the problem definition is to improve the interchange in a manner that avoids or minimizes takings, particularly residential takings. Improvements will also be evaluated in terms of the goals of minimizing visual and noise impacts. Impacts on wetlands should also be minimized. Local access should be maintained or improved for businesses and residential neighborhoods.

3. DEVELOPING AND EVALUATING ALTERNATIVES

Note: In order to accurately convey the decision process that led to the study recommendations, the exhibits in this chapter have not been revised or updated. They represent initial concepts and ideas developed with the ITF. This chapter describes later refinements to the components and preliminary alternatives and their evaluations.

3.1 Approach

A successful plan to improve transportation in the I-93/I-95 Interchange area must proceed from the goals and objectives established with the ITF (Chapter 1) to a set of recommendations that address the identified problems (Chapter 2). In order to make well-thought-out decisions, alternative proposals must be developed and evaluated against the full set of evaluation criteria.

There was early agreement in the Task Force that the alternatives to be considered had to have two characteristics:

- Both highway and non-highway actions would be necessary
- Alternatives should be built up from components

Non-highway actions comprise both public transportation and means of transportation demand management - transit and TDM. That these actions should be part of the final solution reflects the understanding that a fundamental part of the problem is high traffic volumes using the interchange, so reducing the volumes will be helpful to any highway solution. Equally important, transit and TDM provide choices for people making trips and thus improve overall mobility. Making transit and TDM a fundamental part of the plan helps to strengthen a balanced transportation system for the region.

Building alternatives from component parts makes the process more transparent because the components can be individually understood by both the consultant team and the task force before combining them into more complex alternatives. Using components is also more efficient because some can be screened out early in the process as shortcomings are identified. As "fatal flaws" are recognized, the number of components is narrowed down, leaving only those components that best meet the goals of the study.

Figure 3-1 is a diagram of the process used in the study. Developing alternatives proceeded on parallel tracks for highway and non-highway alternatives. On each track, components were explored and screened for suitability. The screened highway components were used to build the highway alternatives; a package of screened transit and TDM components was then combined with the recommended highway alternative.

The strategy for developing alternatives was based on awareness that a successful plan must address the full range of objectives, including avoiding takings to the extent possible. Therefore, the strategy was to build up the solution within the available right of way rather than starting with a preconceived design and slimming it down to reduce impacts. The intent is to solve the problems as fully as possible without undue impacts that would jeopardize essential support for the plan.

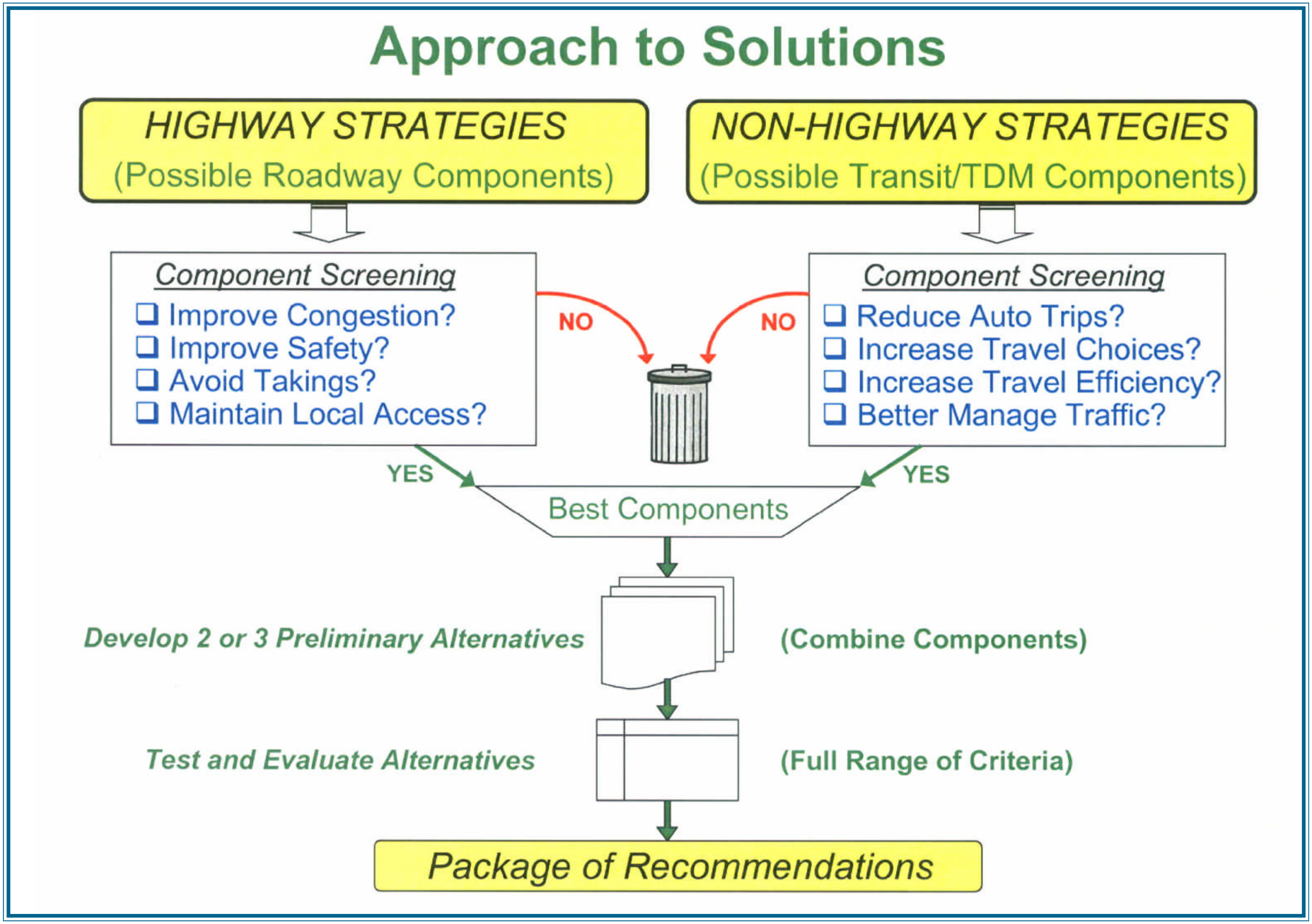


Figure 3-1: Approach to Solutions.

3.1.1 Highway Components

As described in Chapter 2, traffic and safety problems stem from two primary causes: the short weaves within the interchange, and the drop from four lanes to three on the Route 128 northbound just past I-93. Of the interchange weaves, the southbound Route 128 weave between the I-93 on- and off-ramps is the most critical, giving rise to a cascade of back-ups. In addition, the weaves on Route 128 in both directions between I-93 and the adjacent interchanges are problems.

Therefore, the consultant team examined components that would eliminate weaves or reduce the weaving traffic volumes. This could be accomplished by removing one or more loop ramps from the cloverleaf and substituting a direct ramp passing over or under the middle of the interchange, or by separating local traffic on a collector-distributor road (C-D road). And while Route 128 is three lanes in each direction north of I-93, it is possible to move the northbound lane drop further downstream where traffic volumes are lower and backups do not extend into the I-93/I-95 Interchange.

These approaches led to the highway components shown in Table 3-1. The components were screened against four basic criteria. A candidate component for further study should satisfy the following screening criteria:

- Improve traffic
- Improve safety
- Avoid takings
- Maintain all local traffic moves

3.1.2 Ramp Design Speed

It was determined at the beginning of the screening process that substantial takings could not be avoided if proposed ramps were designed for 50 mph, which is the desirable design speed for a system interchange. Since major takings was the primary issue that led to widespread community opposition to the alternatives that were being examined in the previous MassHighway feasibility study, a 40 mph design speed was used to achieve the objective of avoiding takings. This decision recognized that 40 mph ramps are less desirable and would require a design exception from the Federal Highway Administration. This design exception, which would be formally requested during 25% engineering design, is already under discussion with FHWA and MassHighway. However, 40 mph ramps are substantially better than the existing ramp geometry and are also the only way to avoid takings, which was clearly the key to developing a viable project. Using a 40 mph design speed is also the single most important element in developing a context-sensitive design consistent with the MassHighway Project Development Guidebook. More information on the design criteria used in developing the alternatives is located in Appendix B: Engineering Considerations.

3.2 Preliminary Components

Fifteen highway components were examined, as summarized in Table 3-1 and shown in Figures 3-2.1 through 3-2.13.

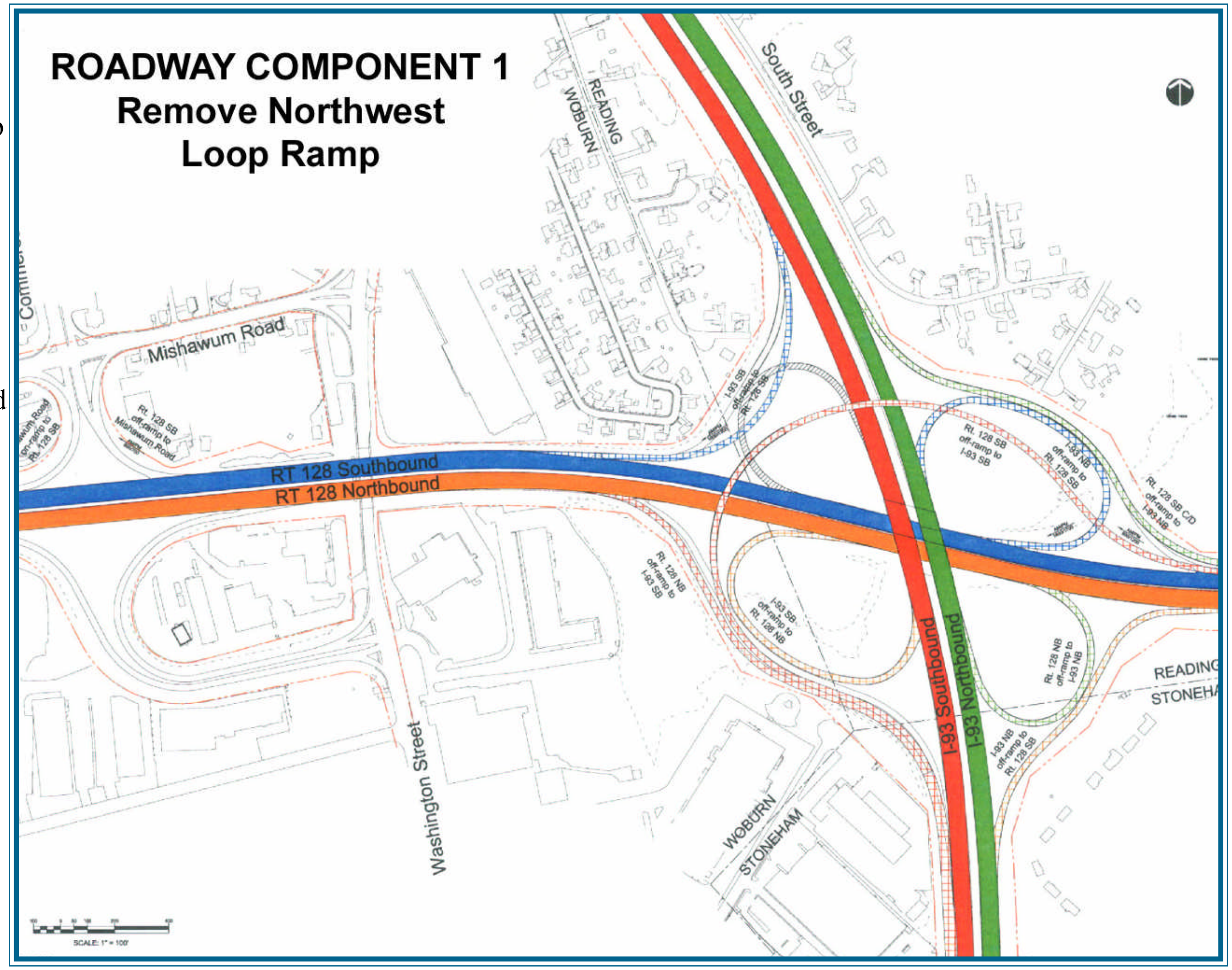
Table 3-1: Screening Matrix for Highway Components.

Component	Improves Congestion?	Improves Safety?	Avoids Takings?	Maintains Local Access?
1. Remove **NW** Loop	yes	yes	yes	All moves maintained
2. Remove **NE** Loop	yes	yes	yes	**I-93 SB** to Mishawum via Commerce Way
3. Remove **NW and NE** Loops	yes	yes	yes	**I-93 SB** to Mishawum via Commerce Way
4. CD road on **128 SB**	yes	yes	yes	**All I-93** moves to Mishawum via Commerce Way
5. CD road on **128 SB**	yes	yes	yes	**I-93 SB** to Mishawum via Commerce Way No access from Rte 28 to I-93 SB
6. Remove **SW** Loop	yes	yes	yes	All moves maintained
7. Remove **SE** Loop	yes, but 128 NB weave shortened	yes	yes	All moves maintained
8. CD Road on **128 NB**	yes	yes	yes	Washington St to I-93 NB must use Commerce Way
9. Extend 4th lane on 128 NB	yes	yes	yes	All moves maintained
10A. CD Roads on both sides on 128	yes	yes	yes	**All I-93** moves to Mishawum via Commerce Way; Washington St to I-93 NB must use Commerce Way
10B. CD Roads on both sides on 128	yes	yes	yes	**I-93 SB** to Mishawum via Commerce Way; Washington St to I-93 NB must use Commerce Way; No access from Rte 28 to I-93 SB
11. Remove **NW and SE** loops	yes, but 128 NB weave shortened	yes	yes	All moves maintained
12. Relocate Washington St ramps to/from 128 NB	Yes, improves 128 NB weave from Washington St on ramp to I-93 off	Yes	One business taking	All moves maintained
13. Mini CD road on 128 NB	Yes – removes NB weave	yes	yes	All moves maintained
14. Begin 128 SB 4th lane at Rte 28	Benefits Rt 28 to I-93 area	yes	yes	yes

Note: Compound components are shaded. The column "Avoids Takings" represents the screening-level evaluation; after further development of alternatives some partial property taking would affect a residential lot in the northeast (1,740 to 4,700 square feet) and a wetland area in the southwest (26,000 of air rights).

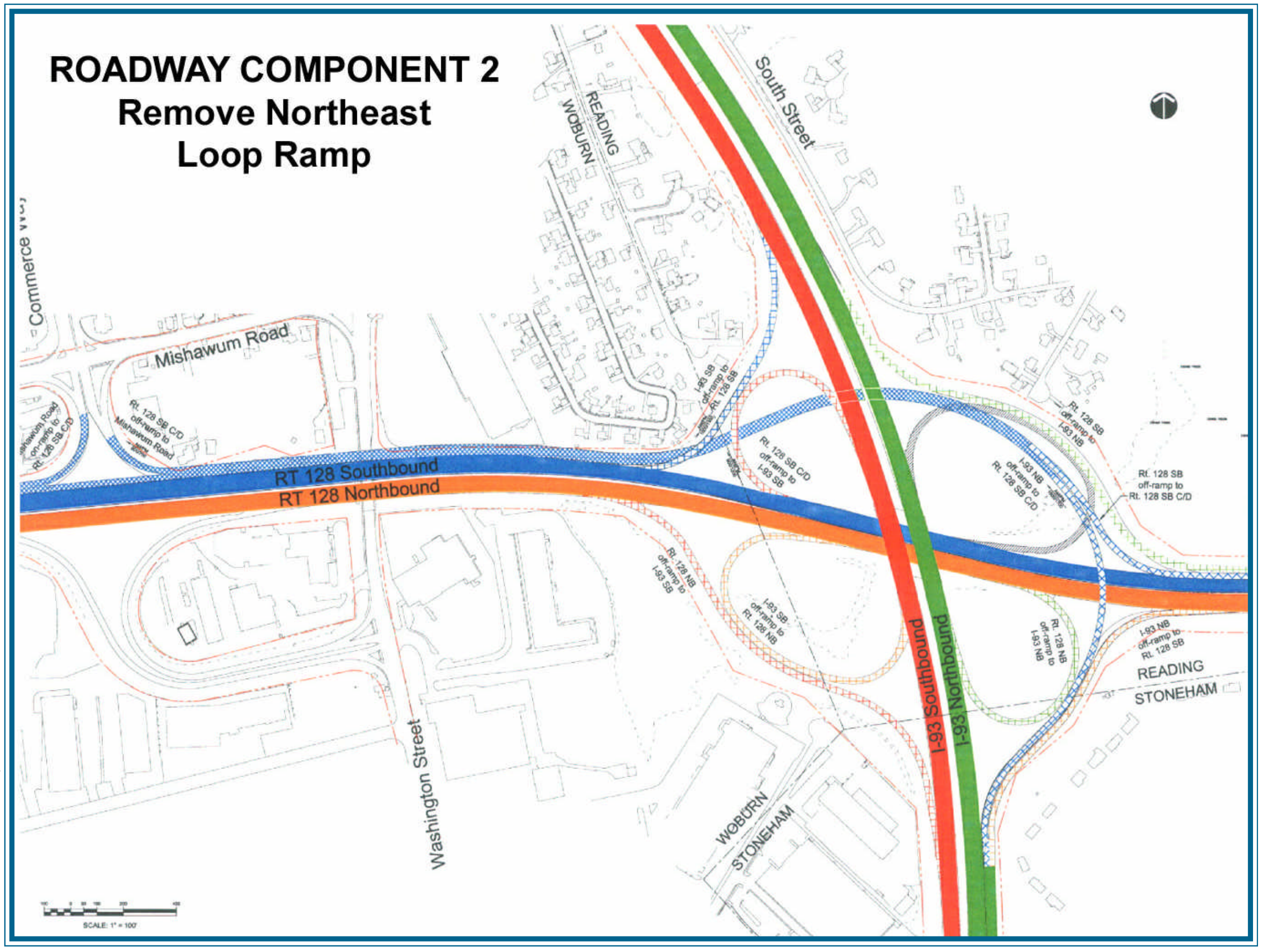
Component 1:
Remove Northwest Loop Ramp

This component removes the weave on Route 128 SB and I-93 SB, and the replacement ramp from Route 128 SB to I -93 SB appears to be geometrically feasible either passing over or under the expressways. Geometry is also improved for the I-93 SB slip ramp to Route 128 SB. Ramps are moved further from the Richard Circle neighborhood, no takings are required, and direct local access is retained in all directions. However, the Route 128 NB and I-93 NB weaves are not addressed.



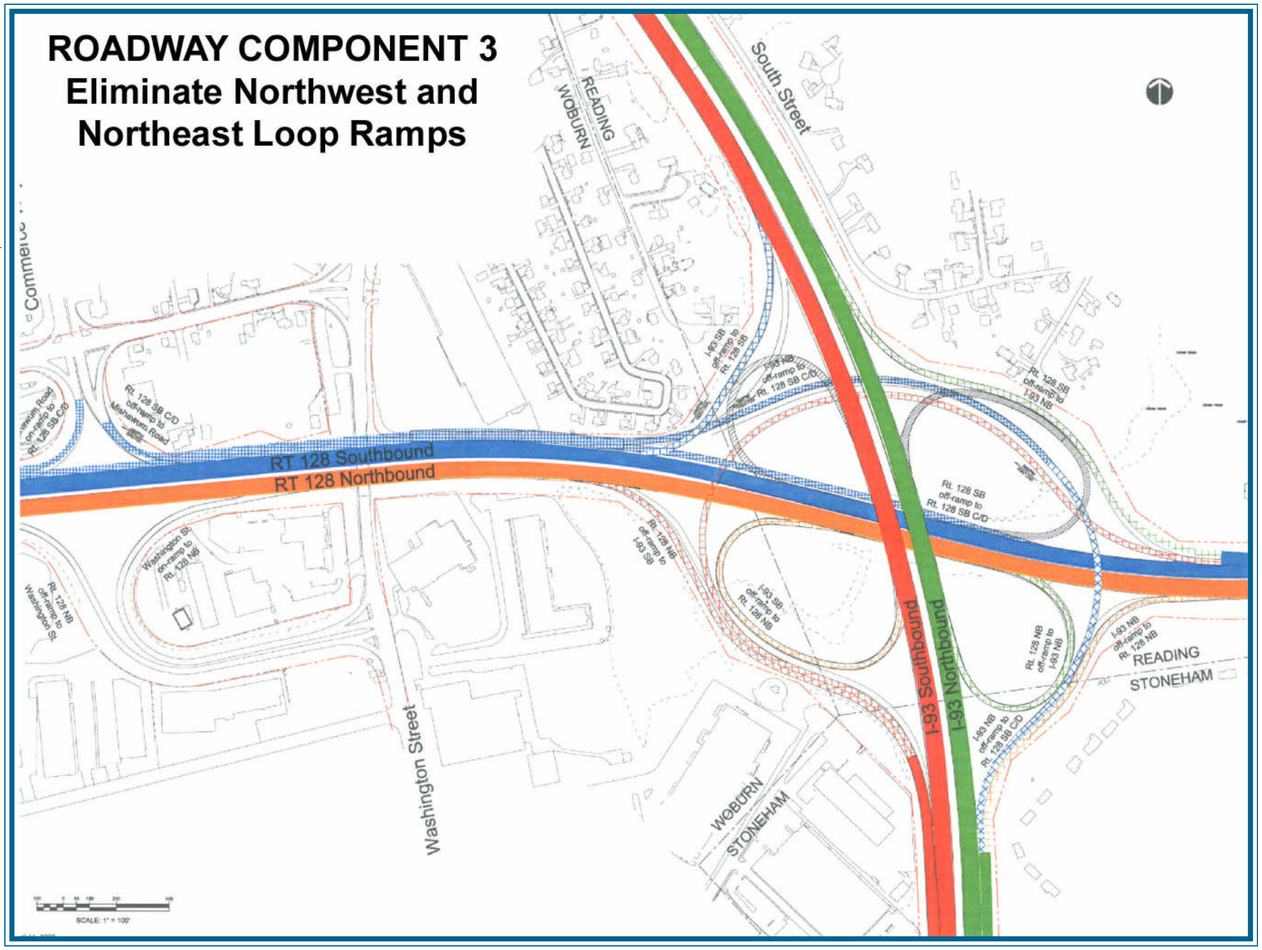
Component 2: Remove Northeast Loop Ramp

This component would remove the Route 128 SB weave and the I-93 NB weave and relocate the Route 128 SB slip ramp to I-93 NB. It appears to be geometrically feasible and does not require takings. However, the replacement ramp from I-93 NB to Route 128 SB must merge with Route 128 in the vicinity of the Mishawum Road off- and on-ramps; this precludes direct access to Mishawum Road from I-93 SB. (Making the ramp from I-93 NB join Route 128 on the left would preclude access from I-93 NB.) Thus, access to the Woburn business district from the north would need to be via Exit 37C and Commerce Way - a situation that was viewed as unacceptable by task force members. In addition, the weave distance from the I-93 NB on-ramp to the Mishawum Road off-ramp would be shorter than the present weave distance at this location. Therefore, this component was eliminated from further consideration.



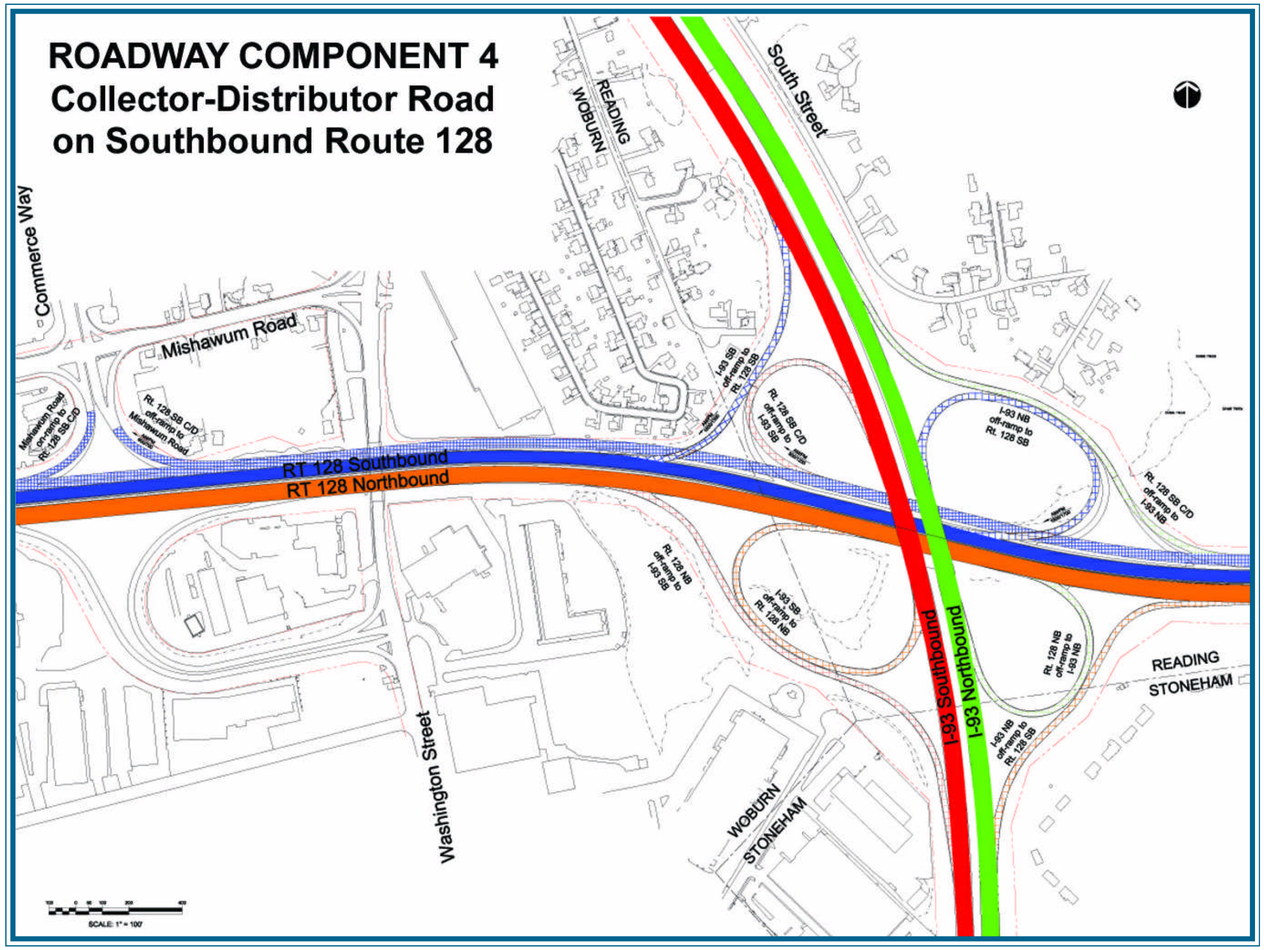
Component 3: Eliminate Northwest and Northeast Loop Ramps

This component would eliminate both loop ramps on the southbound side of Route 128, thus removing all weaves from the interchange. However, like Component 2, direct access from I-93 SB to Mishawum Road cannot be provided, and the weave between the I-93 NB on-ramp and Mishawum off-ramp becomes shorter. For these reasons, the component was eliminated.



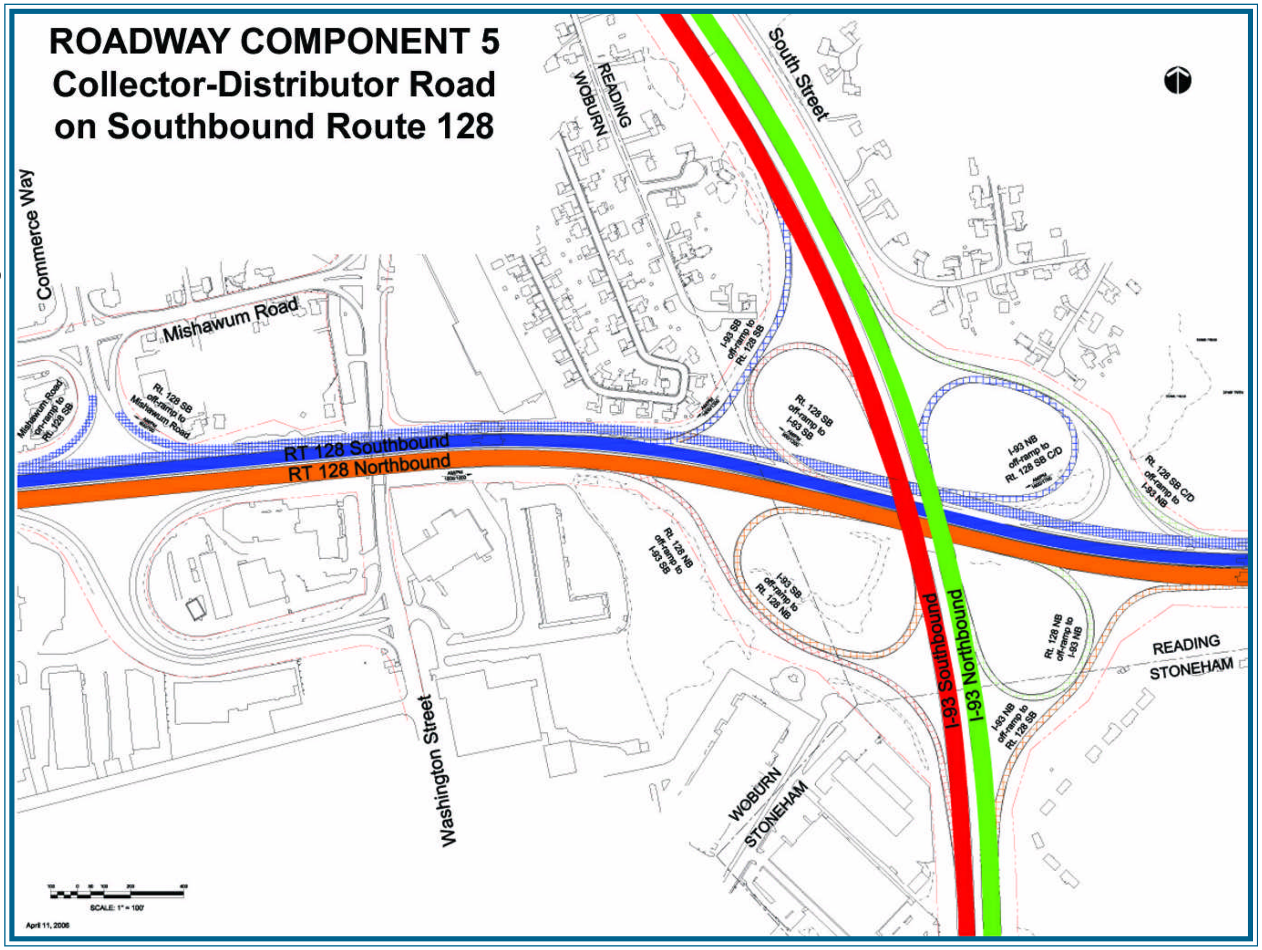
Component 4: Collector-Distributor Road on Southbound Route 128

This component removes the Route 128 SB weave by making access to I-93 SB and Mishawum Road via a parallel collector-distributor road, while access to Route 128 SB from I-93 NB continues to use the northeast loop ramp. The component has no apparent property takings, and would also eliminate the weave to the Mishawum Road off-ramp. However, there would be no direct access to Mishawum Road from either direction on I-93; northbound traffic would need to travel north to Exit 37C and double back to the south via Commerce Way. This indirect access was again viewed as unacceptable to the task force members, and the component was eliminated.



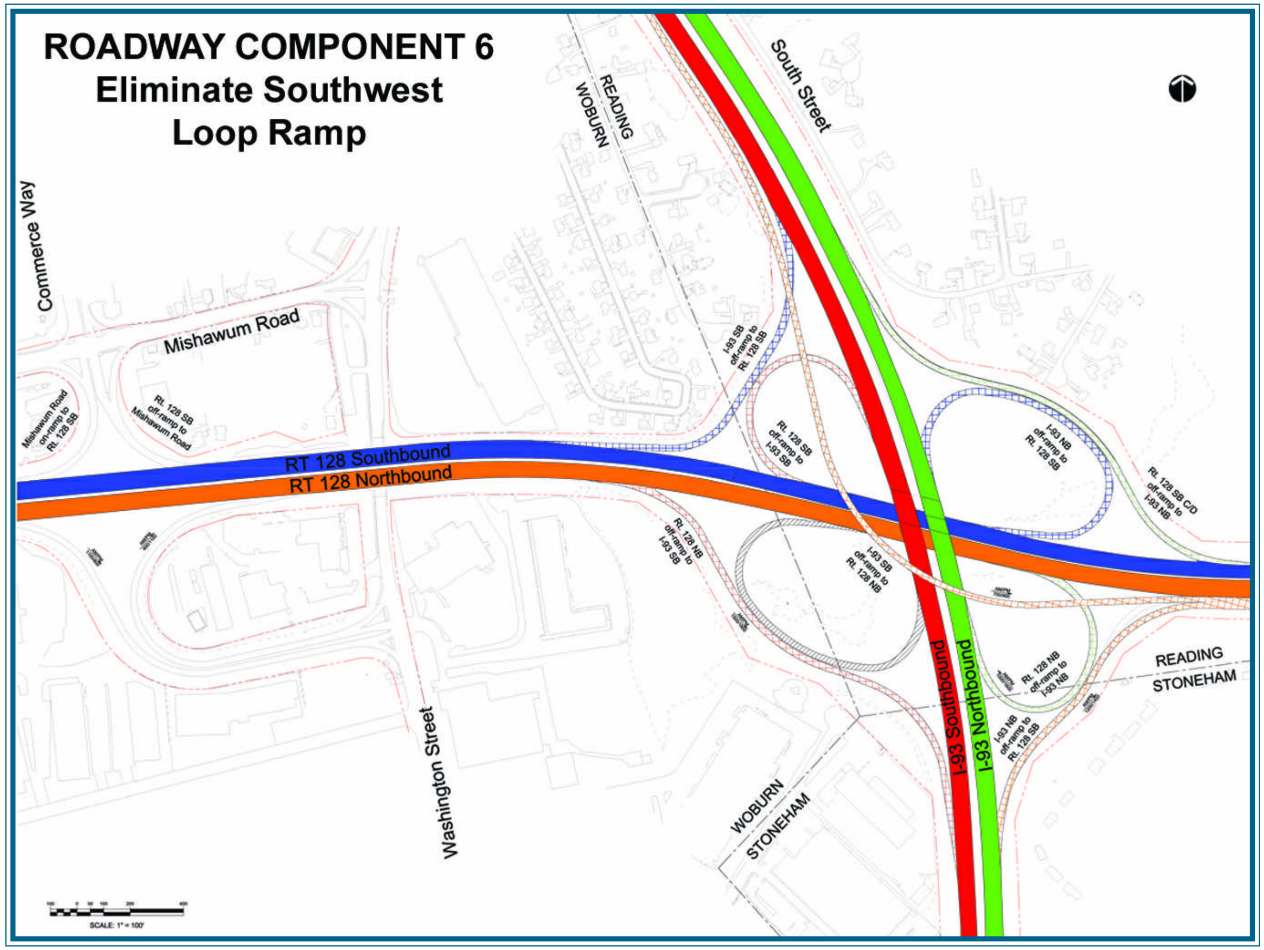
Component 5: Collector-Distributor Road on Southbound Route 128

This component is similar to Component 4 but with the loop ramp connections "flipped" so that I-93 NB connects to Route 128 SB via the C-D road, and access to I-93 SB from Route 128 SB is via a slightly reconfigured loop ramp from the mainline. There is no direct access to Mishawum Road from I-93 SB and no access from Route 28 in Reading/Stoneham to I-93 SB. For this reason, the component was not acceptable and was eliminated.



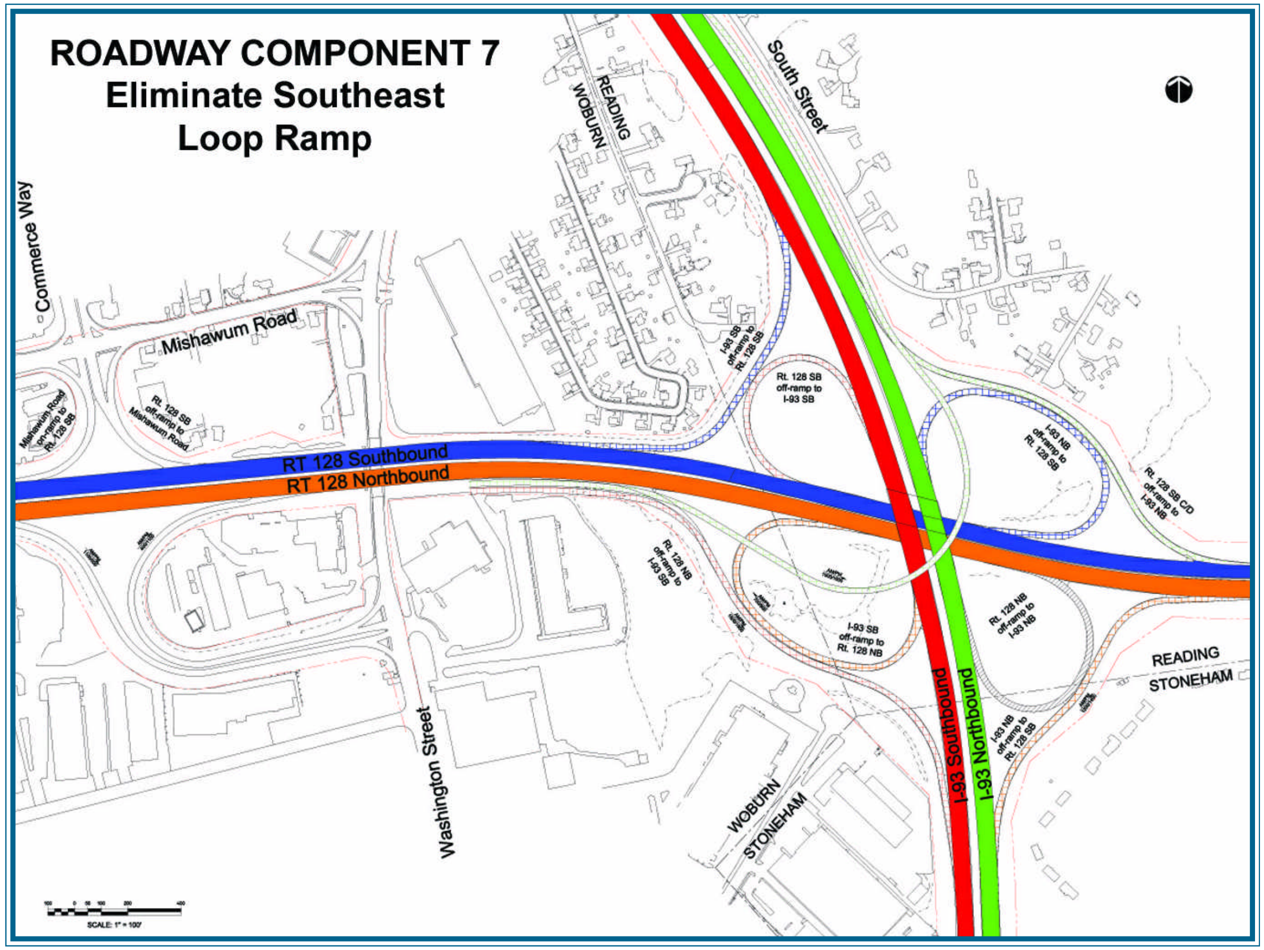
Component 6:
Eliminate Southwest Loop Ramp

This component eliminates the northbound weave on Route 128 and the southbound weave of I-93 by replacing the loop ramp with a semi-direct ramp from I-93 SB to Route 128 NB. No property takings are apparent, and all local movements are preserved. The component does not addresses problems on the southbound side of Route 128, and the short weave between Washington Street and I-93 SB remains.



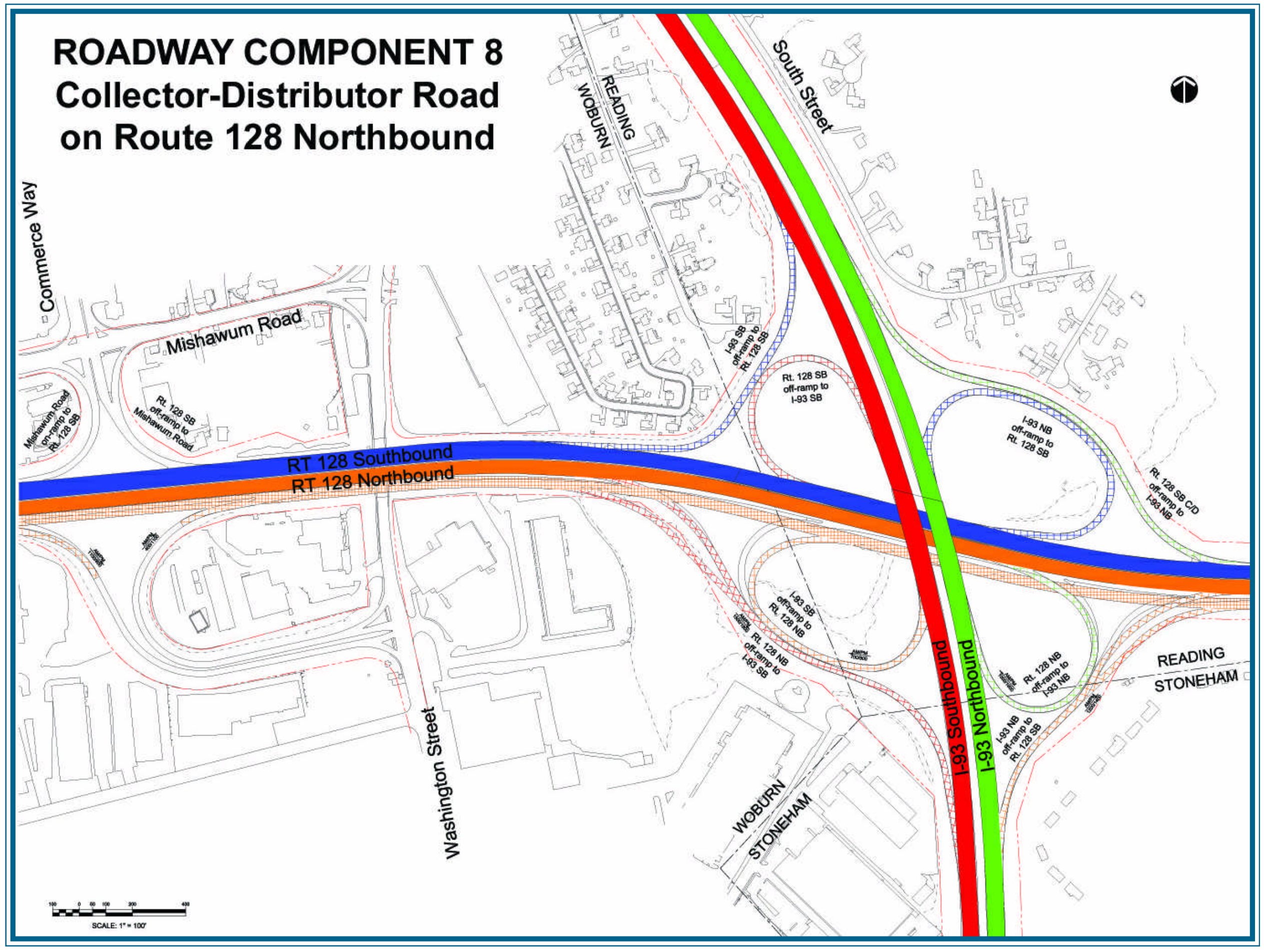
Component 7: Eliminate Southeast Loop Ramp.

This component eliminates the northbound weave on Route 128 between the I-93 ramps and maintains all local moves. The weave between the Washington Street on-ramp and the off-ramp to I-93 SB is made shorter, so this component would also require modification of the Washington Street ramps to be viable (see Components 12 and 13).



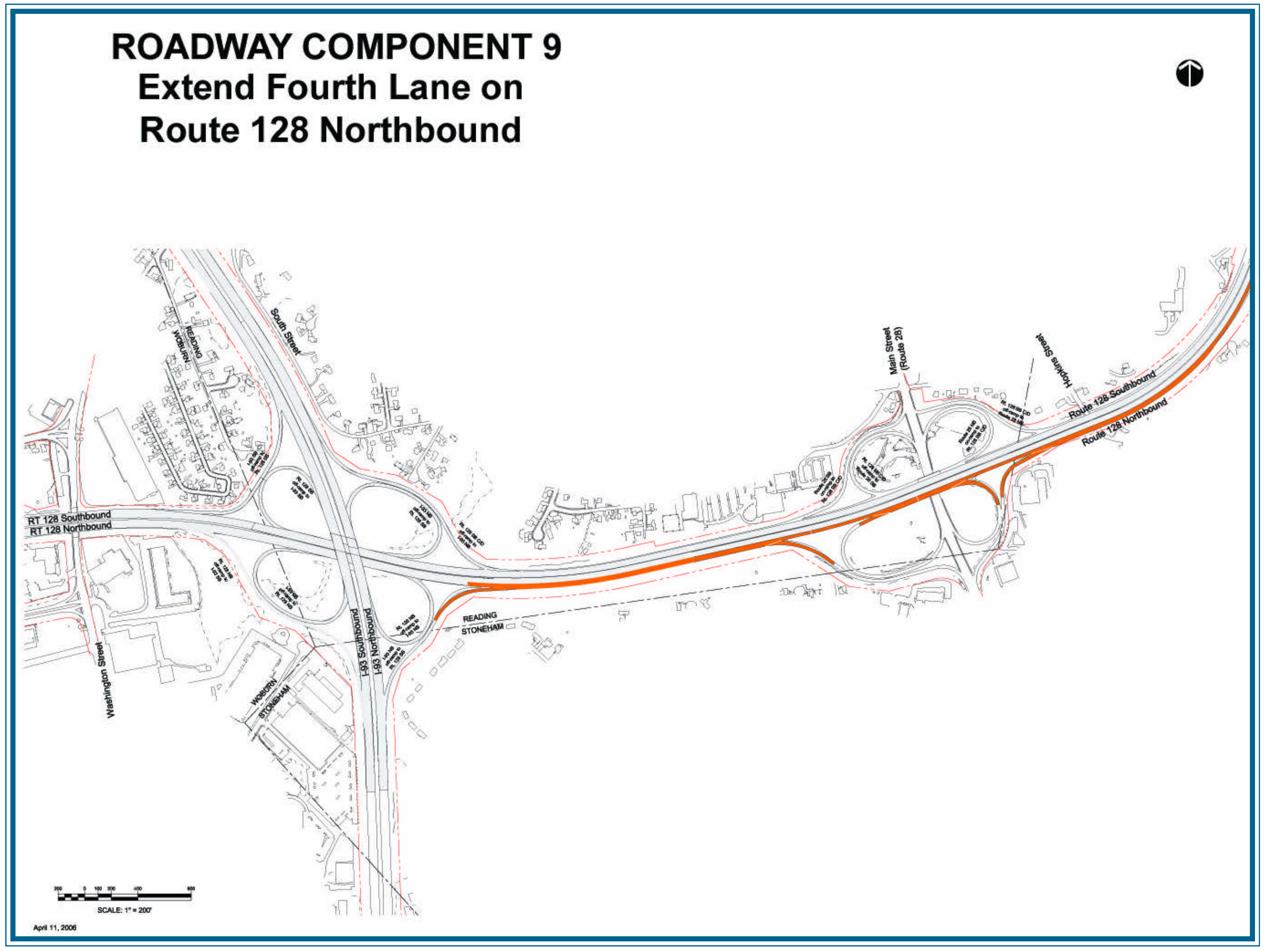
Component 8: Collector-Distributor Road on Route 128 Northbound

This component eliminates the Route 128 NB weave and both I-93 weaves by providing the access from I-93 SB to Route 128 NB via a C-D road; Route 128 NB to I-93 NB would continue to use a slightly reconfigured southeast loop ramp. Because of these ramp connections, there is no direct access from Washington Street to I-93 NB, requiring this connection to be made via Commerce Way and Exit 37C. This loss of direct access was not acceptable to the task force members. The component was thus eliminated.



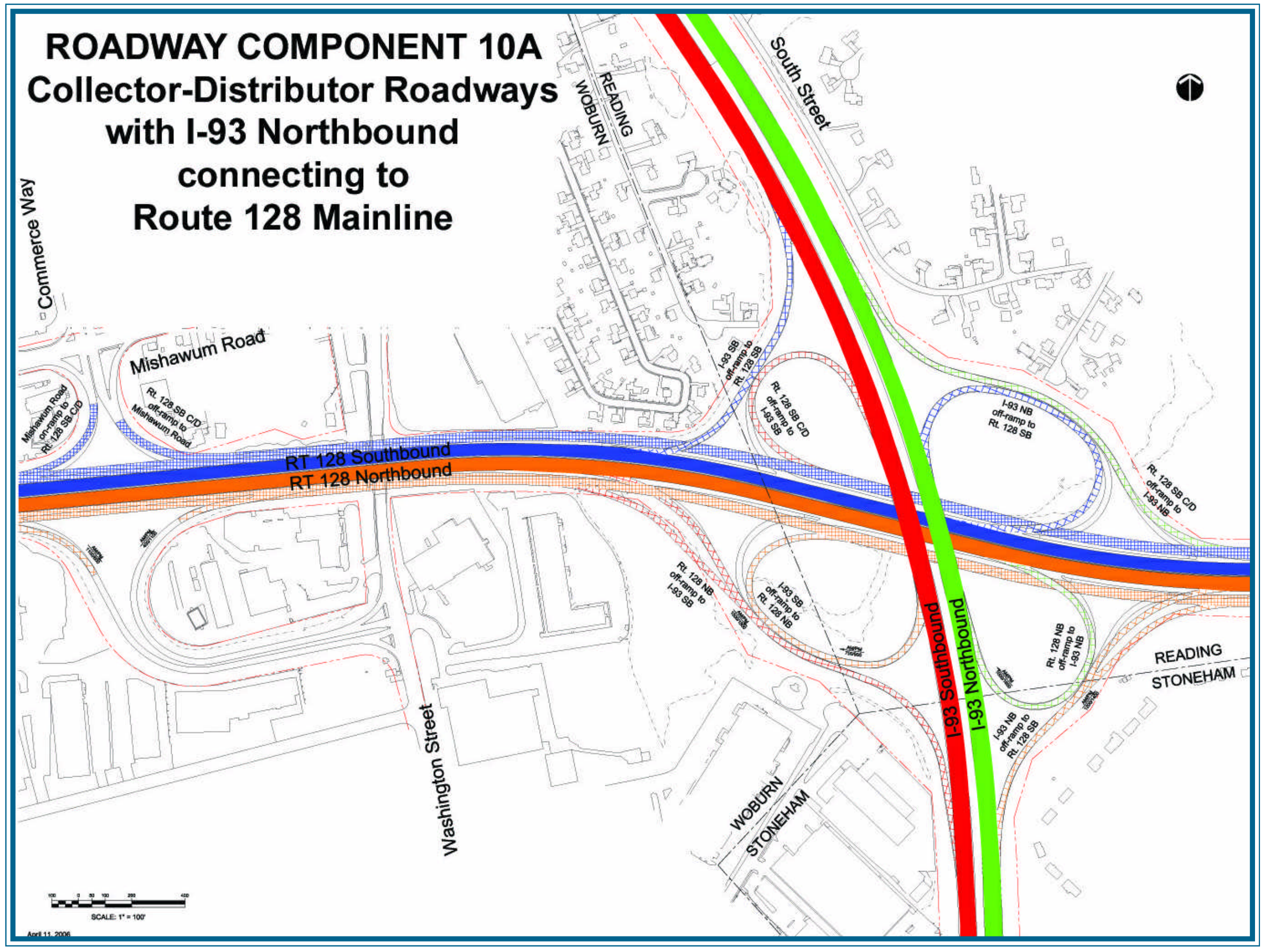
Component 9:
Extend Fourth Lane on Route 128 Northbound

This component addresses the northbound congestion due to the drop from four lanes to three on Route 128 just past I-93. The fourth lane can be extended to Exit 40 (Route 129) in Wakefield, where volumes are lower and the lane drop would have less effect on traffic operations. The existing bridges on Route 128 were designed to accommodate a fourth lane. The component would also improve the weave between I-93 and the Route 28 interchange (Exit 38). This component is compatible with several of the other components.



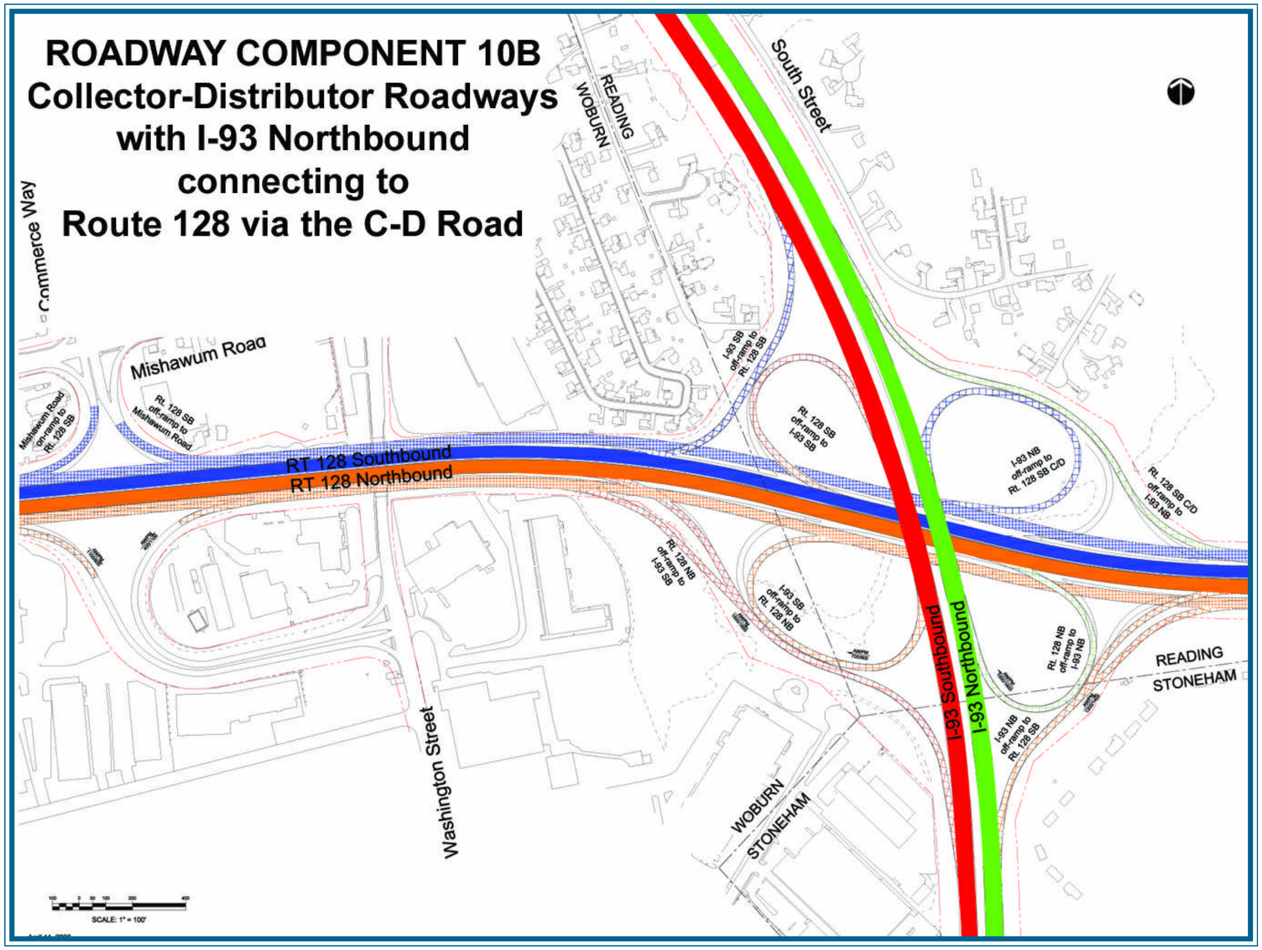
Component 10A: Collector-Distributor Roadways with I-93 Northbound connecting to Route 128 Mainline

This component combines components 4 and 8. It removes all weaves in the interchange as well as the weaves between I-93, Mishawum Road, and Washington Street. However, like components 4 and 8, traffic from I-93 SB and I-93 NB to Mishawum Road must use Exit 37C and Commerce Way, and traffic from Washington Street to I-93NB must use this route in the opposite direction. Because of the lack of direct local access for these movements, the component was eliminated.



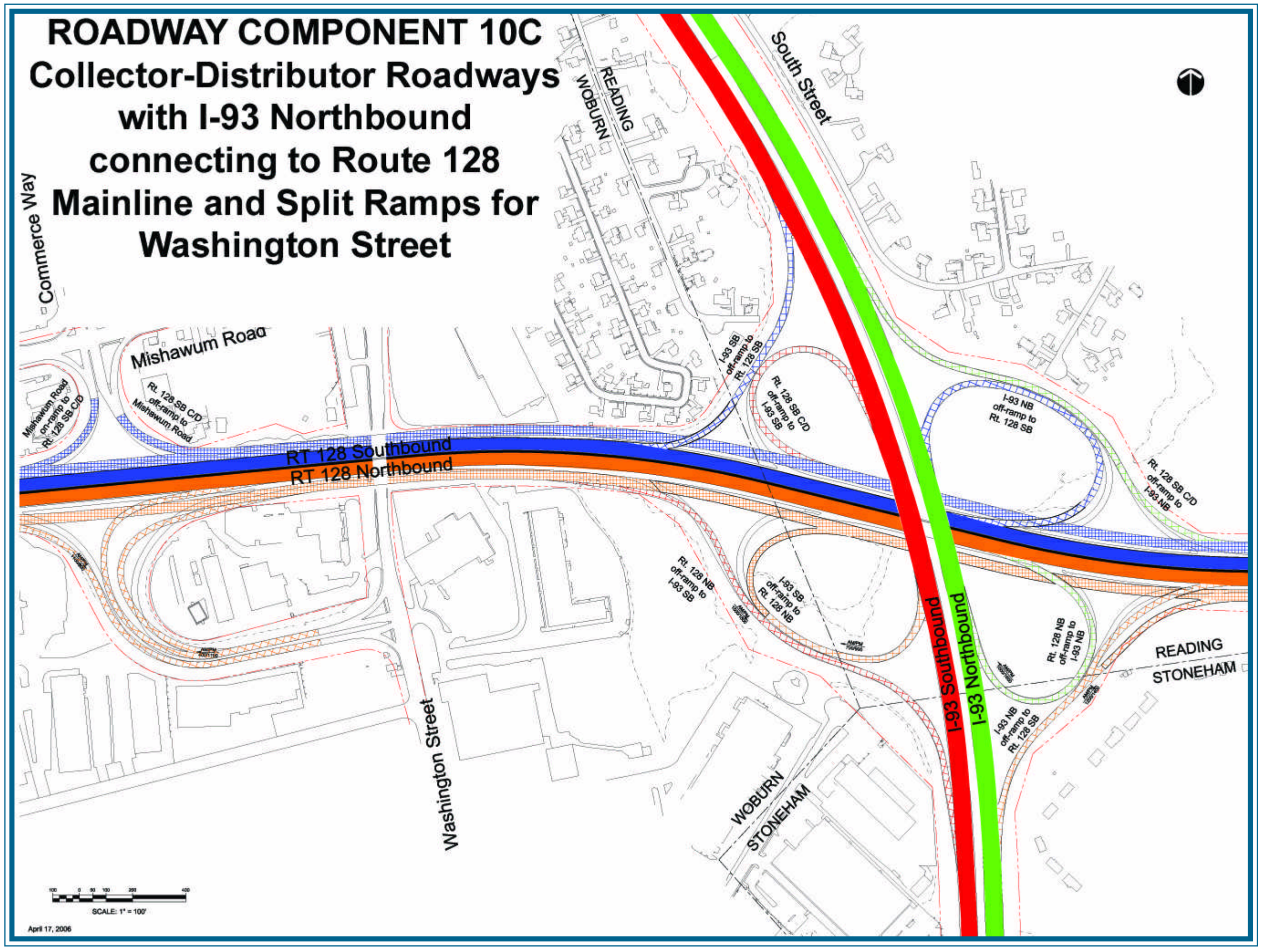
Component 10B: Collector-Distributor Roadways with I-93 Northbound connecting to Route 128 via the C-D Road

This component combines components 5 and 8. While it removes all interchange weaves and local weaves to the west of I-93, Washington Street access to I-93 NB and I-93 SB access to Mishawum Road are both via Commerce Way and Exit 37C, and Route 28 traffic cannot reach I-93 SB. Due to these changes in access, the component was eliminated.



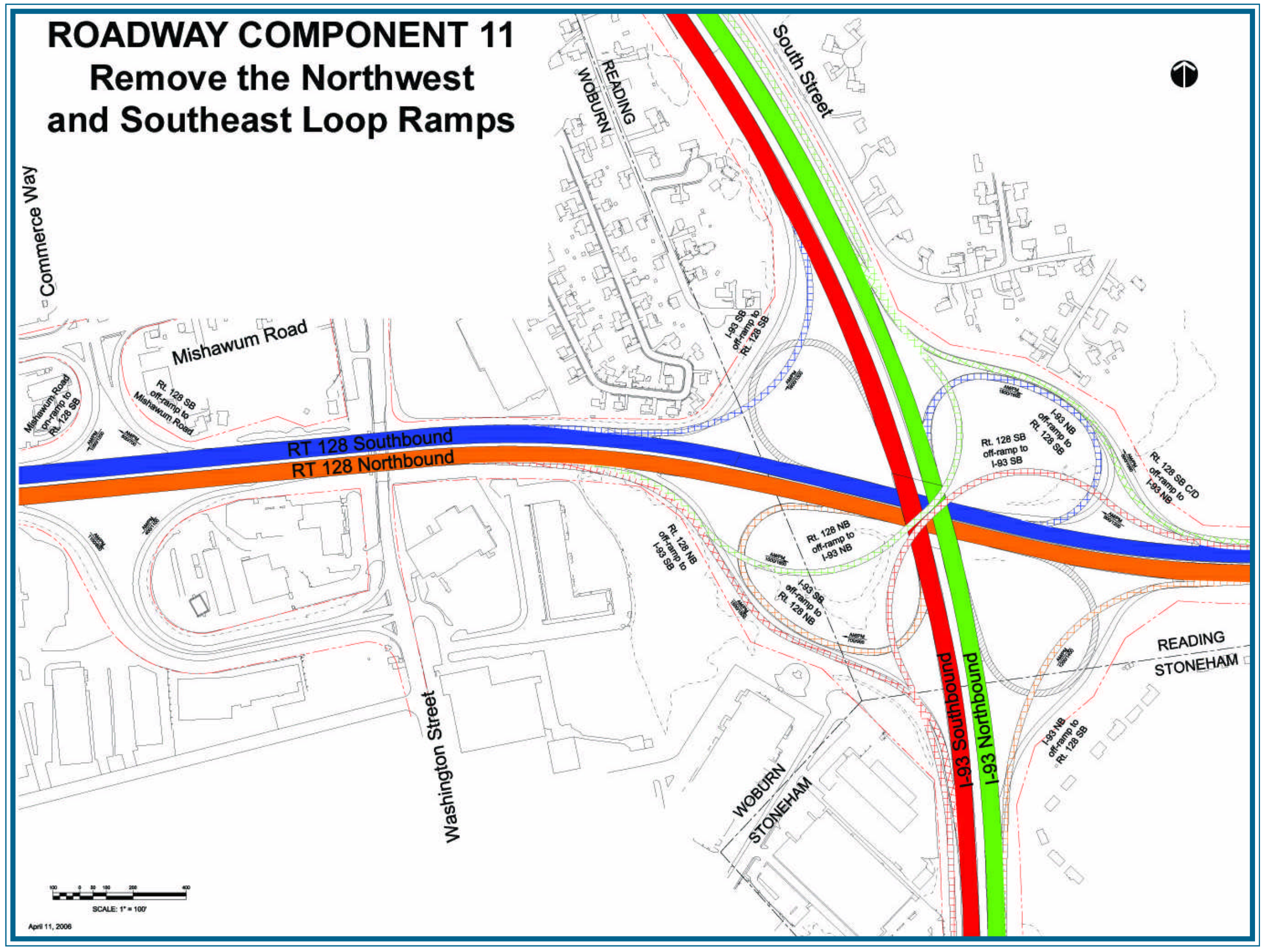
Component 10C: Collector-Distributor Roadways with I-93 Northbound connecting to Route 128 Mainline and Split Ramps from Washington Street

Like Component 10A, this component combines components 4 and 8, but it also adds a split on-ramp from Washington Street to Route 128 and the northbound C-D road, thus providing direct local access to I-93 NB. Access from I-93SB to Mishawum Road remains indirect via Commerce Way.



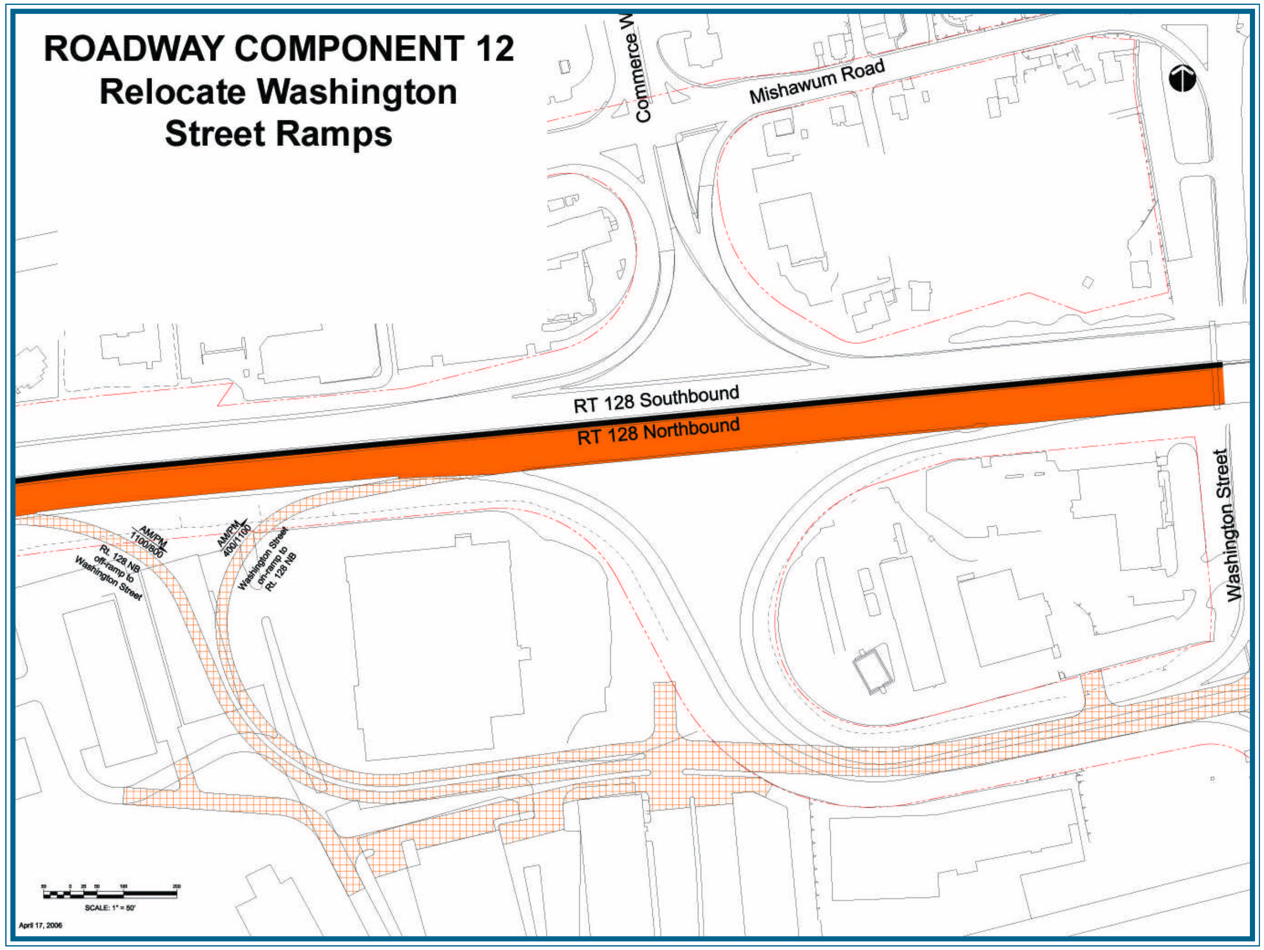
Component 11: Remove the Northwest and Southeast Loop Ramps

This component combines components 1 and 7, eliminating all interchange weaves, and maintaining direct local access for all moves. Its geometry shortens the weave between Washington Street and the off-ramp I-93 SB, requiring the use of component 12 or 13 to address this problem.



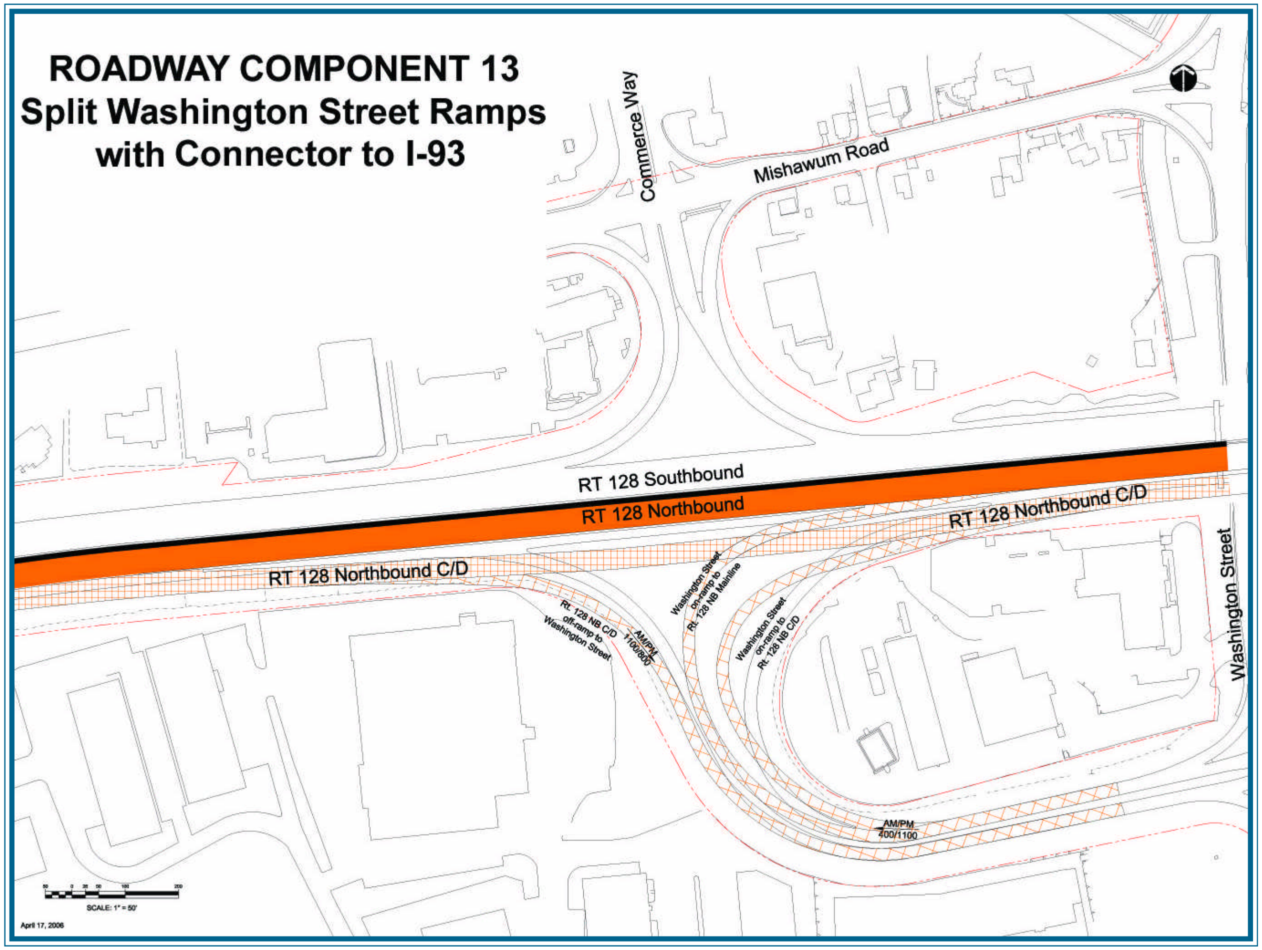
Component 12: Relocate Washington Street Ramps

This component move the Washington Street on- and off-ramps approximately 750 feet to the west, providing adequate weaving distance when combined with Component 7. One commercial building would be taken, and there would be strip takings to provide access to the new ramps.



Component 13: Split Washington Street Ramps with Connector to I-93

This component provides a connector road from Route 128 Northbound which runs parallel to the expressway and divides into ramps to I-93 northbound and southbound. The Washington Street on-ramp is split into separate ramps connection to the I-93 connector and to Route 128 NB. This eliminates the weave from Washington Street to I-93 and also removes traffic from Route 128 NB through the I-93 interchange area. It could be combined with components 7 or 11.

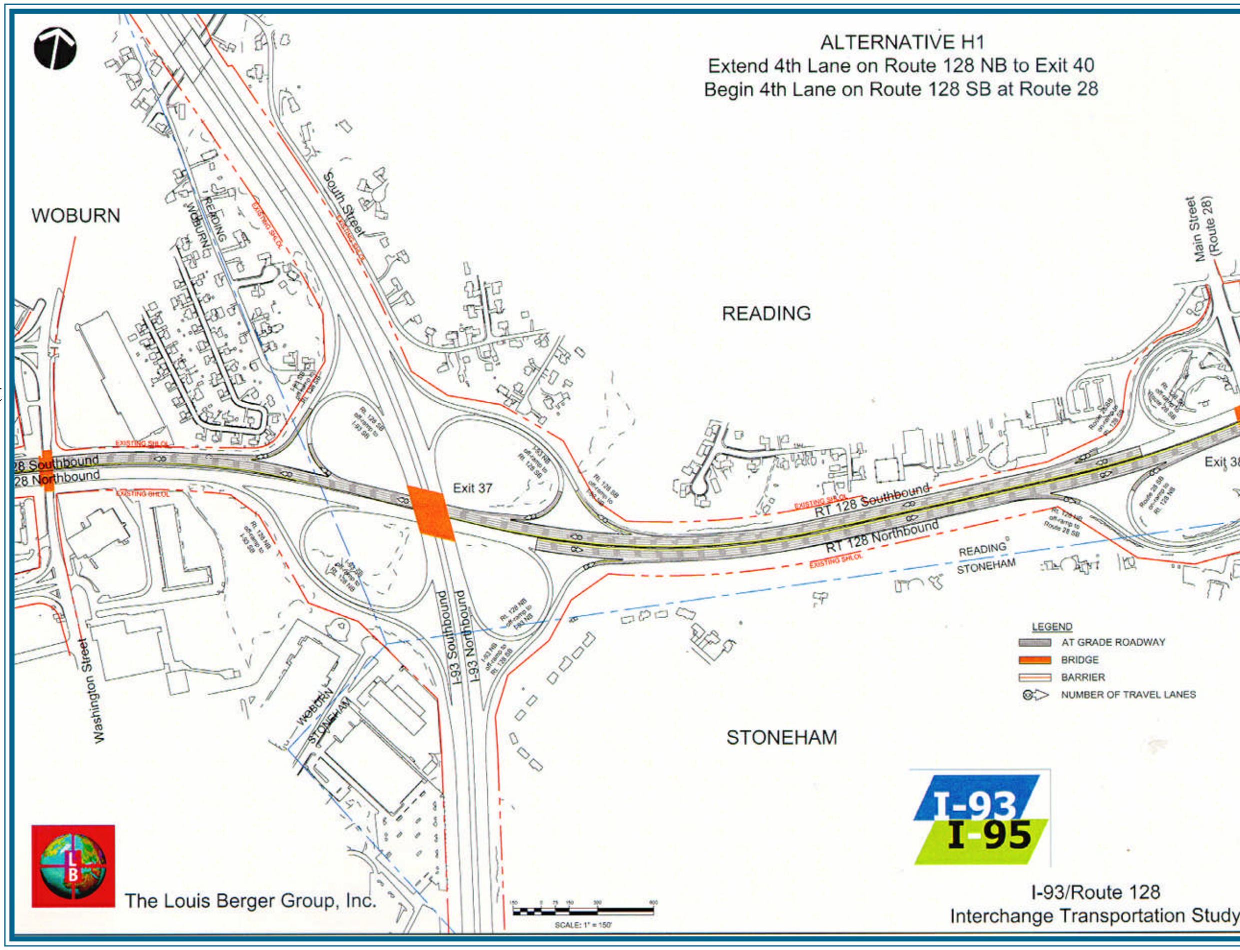


3.3 Alternatives That Resulted from Screening

The screening process concluded with four basic alternatives for detailed study. The alternatives are shown in Figures 3-3.1 through 3-3.4.

Alternative H1

Based on Component 9, this alternative would extend the fourth lane on Route 128 NB to Exit 40 (Route 129) in Wakefield. After discussion with the ITF and preliminary analysis with the CORSIM model, the fourth lane on the southbound side of Route 128 was added from the Route 28 on-ramp at Exit 38; addition of a lane through the I-93 interchange allows through traffic to more easily avoid the merging and diverging traffic in the right lanes, which facilitates the merge from the on-ramp from northbound I-93. It was also noted when the four alternatives were first discussed that H1 could be implemented relatively inexpensively and quickly, and it could serve as an interim improvement for one of the other alternatives.

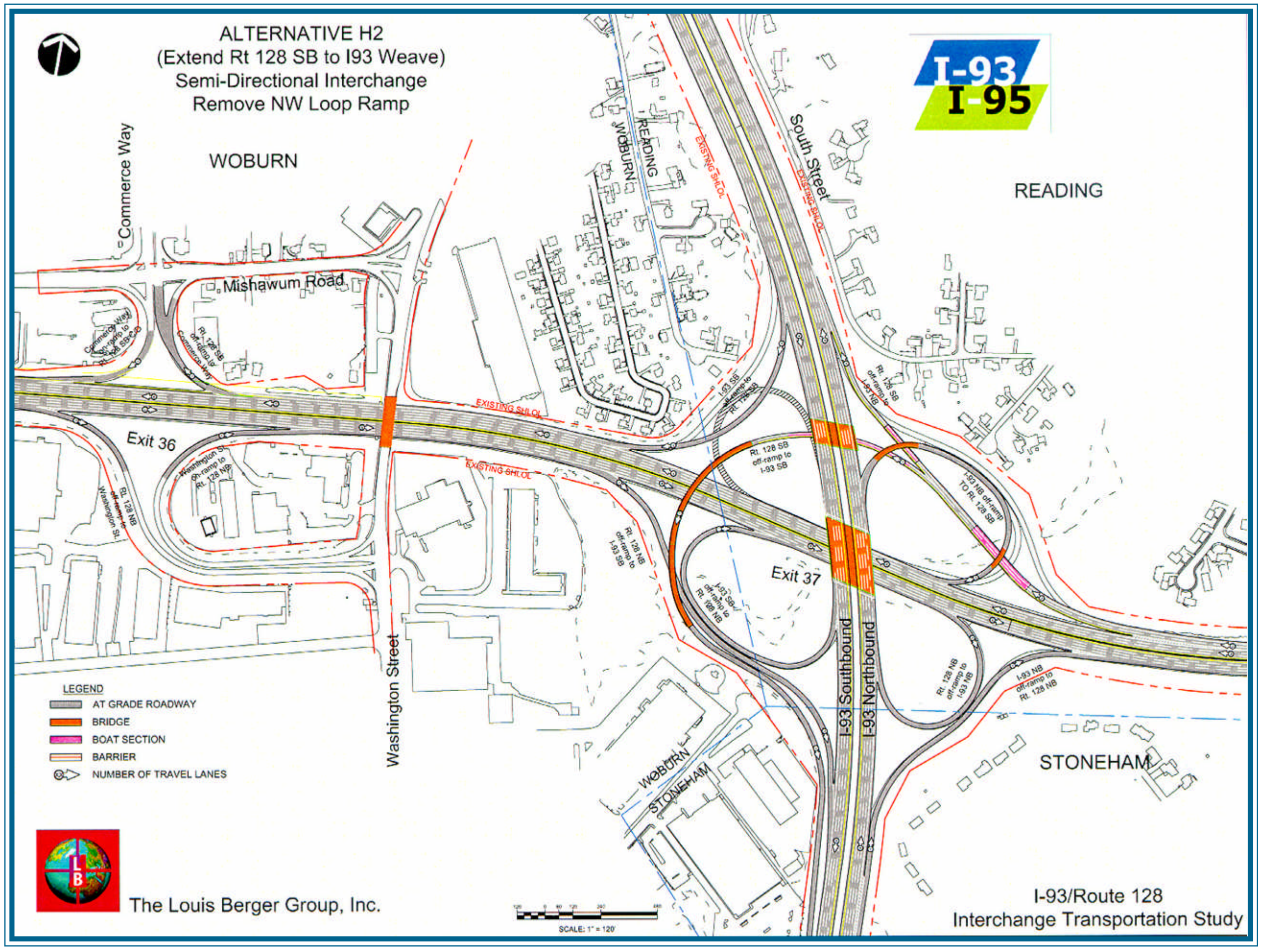


Outcome:
Alternative H1 was recommended as an interim improvement with the addition of a temporary on-ramp from Cedar Street in Woburn to southbound I-93. See Section 4.1.5.

Alternative H2

This alternative would remedy the southbound weave on Route 128, which leads to back-ups that cascade around the interchange as described in Chapter 2. The alternative is based on Component 1 (removal of the northwest loop ramp), with improvements to the acceleration and deceleration lanes in the northern half of the interchange (i.e., Route 128 southbound). It also eliminates the weave on I-93 SB and realigns the slip ramp from I-93 SB to Route 128 SB, moving it further from the Richard Circle neighborhood.

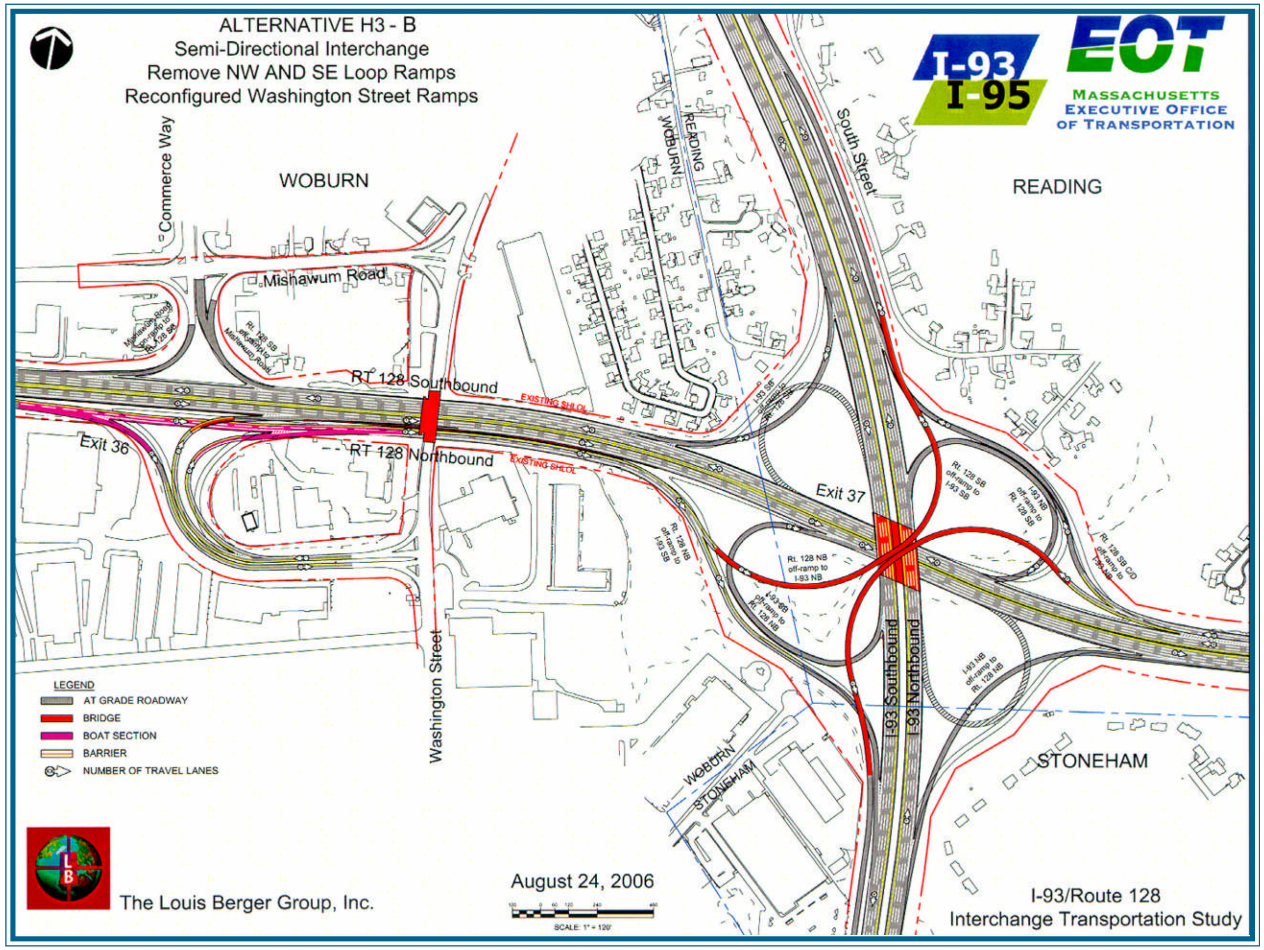
Outcome:
Alternative H2 was not advanced because it addresses only the northern half of the interchange (southbound Route 128).



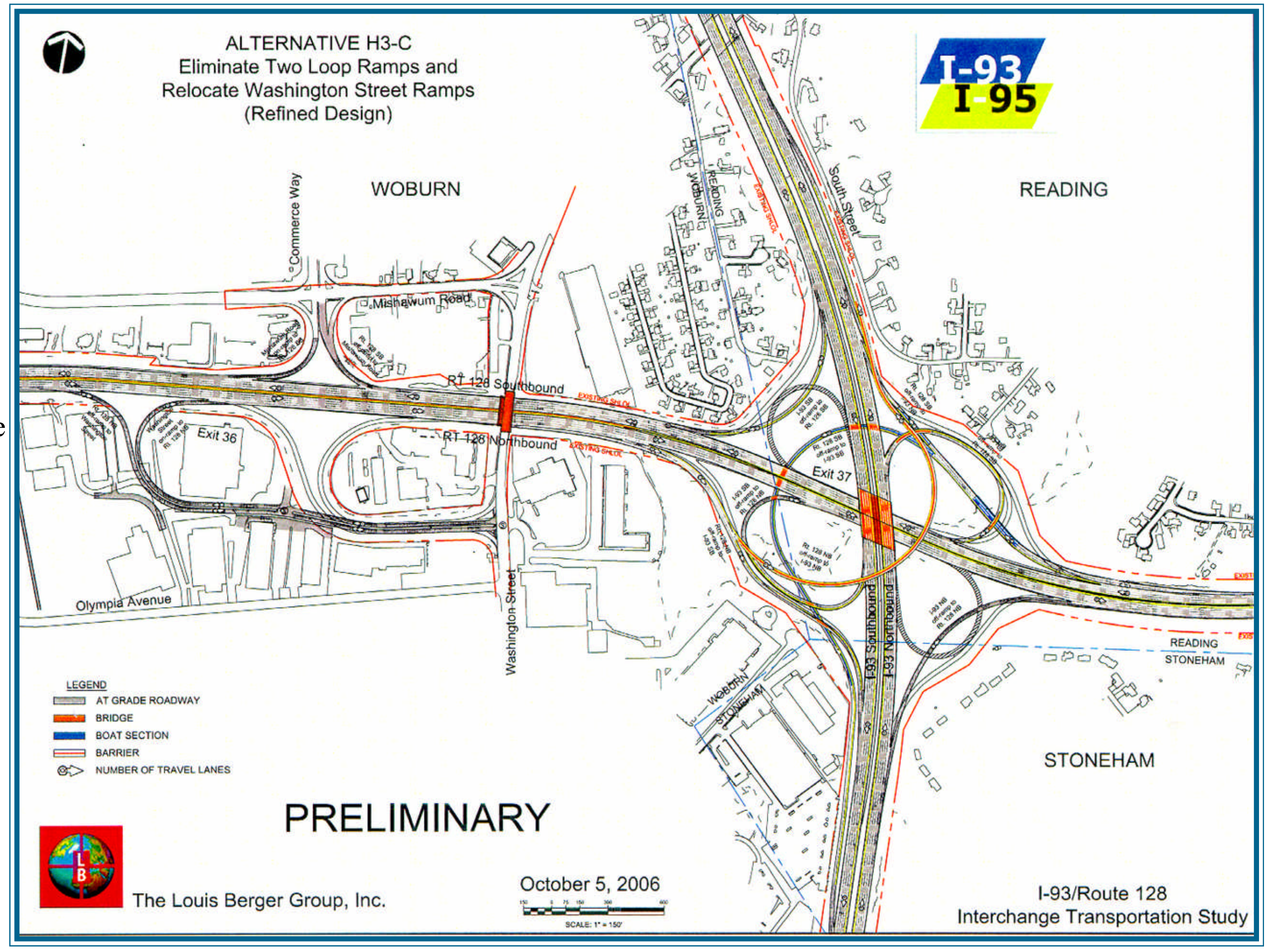
Alternative H3

Alternative H3 is a family of alternatives based on components 1 and 7. It eliminates all interchange weaves by removing the northwest and southeast loop ramps, improves all acceleration and deceleration lanes, and improves the geometry of the northwest and southeast slip ramps, moving them further from the adjacent neighborhoods in Woburn and Stoneham.

Two types of variations on the basic plan of Alternative 3 were explored. As discussed above, Component 7 by itself would shorten the weave between the Washington Street on-ramp and the Route 128 off-ramp to I-93 SB. Alternative H3 addresses this weave in two ways, by using Component 12 to relocate the Washington Street ramps to the west or by using Component 13 to eliminate the weave with split ramps from Washington Street to Route 128 NB and to an I-93 connector road.



The second source of variation was in the configuration of the semi-direct ramps that replace the eliminated loop ramps. In one version, both ramps pass over I-93 and Route 128; in the other version, the ramps overlap, with one ramp (Route 128 SB to I-93 SB) passing under both expressways, and the other ramp (Route 128 NB to I-93 NB) passing over both expressways.



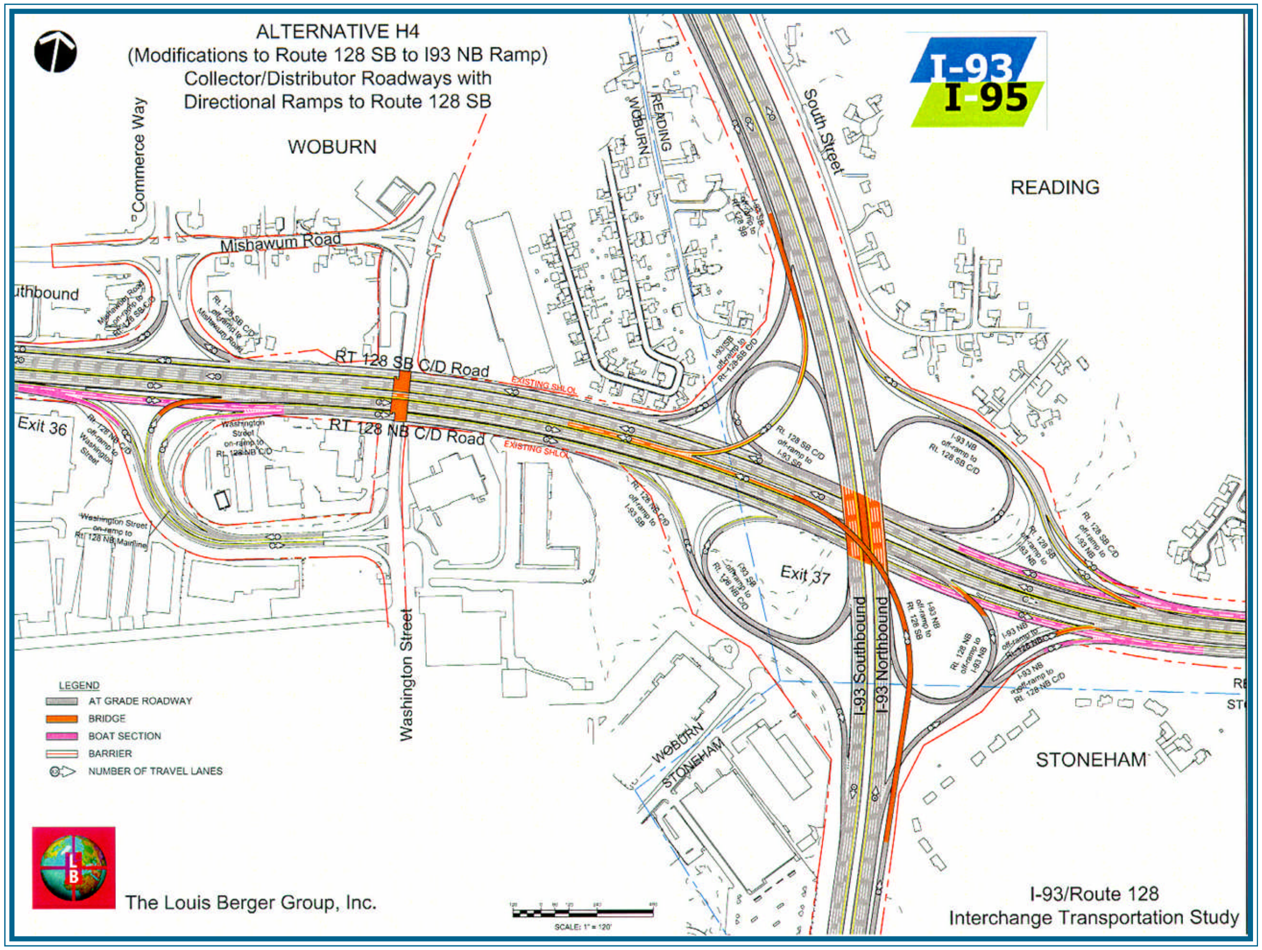
Combining the Washington Street variations with the two possible ramp configurations results in four basic variations within Alternative H3, as shown in Table 3-3. Note that the "OS" and "US" nomenclature was developed after the initial round of evaluations in which the early version of H3-UR was called H3-C and the early version of H3-OS was called H3-B. (H3-A corresponds to H3-OR.)

Note: At the time the alternatives were evaluated, traffic operations issues existed in the versions of this alternative with split ramps from Washington Street, making the relocated Washington Street ramps appear to be preferable. These issues were later resolved during further development of the alternatives, leading to the recommendation of H3-OS and H3-US and the elimination of the versions with relocated Washington Street ramps.

Outcome:
Alternatives H3-OS and H3-US were recommended for detailed study in the environmental phase of project development. See Section 4.1.

Alternative H4

This alternative uses collector-distributor roads as explored in components 4, 5, 8, and 10, but with a modification that preserves all local access. Alternative H4 has a collector-distributor roadway on both sides of Route 128. On the northbound side of Route 128, the off ramp to I-93 NB is from the mainline, while the on-ramp from I-93 SB is to the collector-distributor road in the same manner as component 8. The feature added to the previously studied components is that access from both directions on I-93 to southbound Route 128 is via an elevated "wishbone" ramp that runs parallel and to the left of the southbound through-lanes on Route 128. This is not a left-hand entrance, but rather a major fork in which two lanes from I-93 join the three lanes on Route 128 SB to form a five-lane section, with the right-most lane dropping after the Mishawum Road on-ramp to continue as the existing four southbound lanes of Route 128. Access to the southbound collector road is provided from both directions on I-93, and split ramps from Washington Street provide access to Route 128 and both directions on I-93. Thus, direct access to and from the expressways is provided for all local movements. A split ramp from I-93 NB to Route 128 NB and the collector road provides access to Route 28 without a weave. Access from Route 28 to Route 128 SB and both directions on I-93 is provided via the southbound collector road.



Outcome:
Alternative H4 was not advanced because of its complexity and cost and the better performance of Alternative H3.

3.4 Evaluation of Alternatives

3.4.1 Methodology

The preliminary screening of highway components was qualitative in nature: traffic and safety improvements were inferred from the elimination of weaves and improved geometry. The preliminary components had been developed using CAD, so that conformance to geometric design standards, maintenance of local access, and potential right-of-way impacts could be evaluated with a relatively high degree of accuracy. Thus, the components that were combined into the four final alternatives were well understood before they were combined into alternatives.

Evaluation of the four alternatives H1-H4 was more quantitative. A major tool for evaluating traffic operations was the microsimulation model (using CORSIM) that had been developed and calibrated in the analysis of existing conditions and the 2025 No-Build case (see Chapter 2). The CORSIM model was employed interactively with the design and refinement of the alternatives so that the design of each alternative could be made as effective as possible.

CORSIM provides several summary measures including the number of vehicles processed in the morning and afternoon peak hour, aggregate travel time, and vehicle density (a measure of congestion), which are indicators of traffic operations that allow comparison between the alternatives. In addition, CORSIM provides an animated display of the simulation results, which can be used to visually identify locations where queues would occur. This feature was used both to optimize the design and to display the results for the ITF and at public meetings.

In addition to CORSIM, the traffic operations for the interchange alternatives were analyzed using the level of service methodology of the Highway Capacity Manual and the associated HCS software.

There was considerable discussion in the ITF of the potential for quantifying the results of safety improvements. As discussed in Chapter 2, there is currently no available model or methodology for estimating crash reduction at major highway interchanges. However, a quantitative measure that was used in the evaluation was the percentage of crashes that were associated with each merge, diverge, and weave in the existing interchange (based on 2002-2004 crash data described in Chapter 2). The alternatives were evaluated in terms of the percentage of crashes that were addressed by eliminating weaves or by improving the geometry of merges and diverges. CORSIM also was used to provide a measure of the speed differential between the fastest and slowest lanes; with other factors equal, the potential for crashes decreases as the speed differential decreases.

In addition to these analyses, the following methods were used to evaluate the alternatives:

- **Mobility:** a qualitative assessment based on overall travel time and assuming the transit and TDM improvements as means to increase regional mode choice.
- **Local traffic:** Level of service analysis of intersections adjacent to the interchange as well as CORSIM measures of additional vehicles processed on the expressways, which would encourage some of the traffic diverting via local streets to return to the expressways.
- **Takings:** Direct inspection of the CAD layouts.
- **Wetland impacts:** CAD analysis overlaying the alternatives on the wetlands within and around the interchange, using the surveyed MassHighway base map.
- **Noise:** A qualitative assessment based on the traffic volumes and three-dimensional geometry of each alternative.
- **Visual impact:** A 3D computer model using the engineering CAD drawings to develop ground-level simulations of the alternatives as they would appear from vantage points near the interchange.
- **Economic impact:** A quantitative estimate of the value of time lost due to delays at the interchange, based on CORSIM results and Census data.
- **Constructability:** A qualitative engineering judgment of the relative complexity and difficulties in staging construction.
- **Cost:** A conceptual cost estimate of each alternative applying current construction unit costs for at-grade roadway, bridge, and below-grade construction together with quantity take-offs using the CAD plans.

The results were reviewed at ITF meetings and at the October 2006 public meeting, and were summarized into an evaluation matrix that allowed an at-a-glance comparison of the alternatives.

3.4.2 First-Round Evaluation

Summary of Traffic Operations

The alternatives for detailed evaluation initially had single-lane ramps for all movements; these were later widened to two lanes where the available right-of-way permitted, and the analysis was repeated for the refined versions as described in Chapter 4. Two versions of Alternative H3 were tested: H3-B (H3-OS) had two fly-over ramps and used a split Washington Street on-ramp. H3-C (H3-UR) had one semi-direct ramp passing under I-93 and Route 128, one ramp passing over, and relocated Washington Street ramps further to the west in order to lengthen the weave between the Washington Street on-ramp and the off-ramp to I-93 SB. Evaluations of the final versions of H3 are described in Section 4.1.

The major finding is that Alternatives H2, H3, and H4 all substantially improved traffic flow and reduced travel time, particularly for the major movements between Route 128 and I-93. The CORSIM analysis showed that Alternative H1 providing the expected improvement on northbound Route 128 by moving the lane drop to Exit 40; the other alternatives also include the extension of the fourth lane and improve traffic flow and travel time on northbound Route 128. Alternative H1 performed better than expected on the southbound side of Route 128, delaying but not entirely preventing the formation of cascading queues that gridlock the interchange. Alternative H2 substantially improved traffic flow by eliminating the weave on southbound Route 128 which is the place where the cascading queues originate.

Alternative H3-B improved the interchange but had areas of queuing on Route 128 southbound where traffic to I-93 must divide onto northbound and southbound ramps; Alternative H3-C's profile permitted a longer segment for exiting traffic to sort itself into the two directions and did not experience this problem. Alternative H3-B also had substantial queuing on northbound Route 128 where a large volume of traffic exited to the connector road serving both directions of I-93 as well as the off-ramp to Washington Street; H3-C did not require this volume of exiting traffic to leave Route 128 at a single point and did not experience the problem. Based on these differences, Alternative H3-B was set aside but not dropped from consideration pending work to refine the two problem areas. Alternative H3-C was the version presented at the public meeting held in Reading in October 2006.

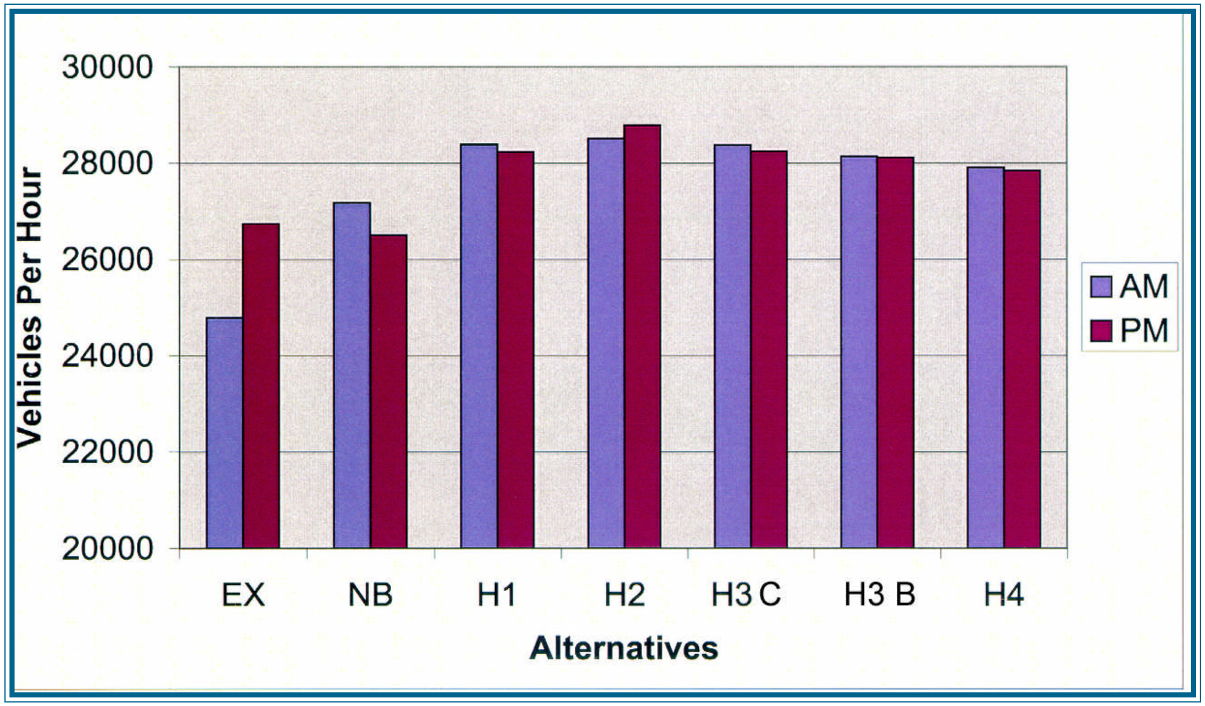
Alternative H4 had very good traffic flow on Route 128, but because the volumes to and from I-93, Route 28, Washington Street, and Mishawum Road were actually higher than the through volumes on Route 128, there was some congestion on the collector-distributor roads in each direction.

These traffic operations results are described in more detail on pages 67-71.

Vehicles Processed

The number of vehicles that would be processed by each alternative was estimated with CORSIM and compared to existing conditions and the 2025 No-Build (See Figure 3-4). While approximately 10 percent more vehicles can be processed in the No-Build case in the morning peak hour than in the existing condition, the volumes that can be processed in the No-Build are actually one percent lower than existing afternoon peak hour due to downstream congestion. Because they improve traffic flow at the interchange, all four alternatives increase the number of vehicles processed by four to eight percent in the morning peak and 13 to 15 percent in the afternoon peak hour. However, the downstream constraint of the existing number of lanes on Route 128 west of the interchange and I-93 north and south of the interchange limit the degree of improvement. This constraint is important because it also limits the amount of traffic that must be processed by the improved interchange, particularly on the two remaining loop ramps in Alternative H3. (Although these loop ramps cannot be widened to two lanes without being enlarged beyond the existing highway right-of-way, CORSIM showed traffic flowing well on the loops despite high lane volumes.) In both peak hours, H4 performs slightly less well than the other alternatives.

Figure 3-4: Comparison of Alternatives, Total Exiting Volume.



One result that could be directly observed in the CORSIM simulation was that Alternative H1 improves the operation of the interchange because it adds an auxiliary lane on the southbound side of Route 128 through the interchange area; this lane permits through traffic to pass by the slower weaving traffic and thereby facilitates traffic entering Route 128 from the loop ramp from I-93 NB; this delays (but does not entirely prevent) the formation of queues that cascade around the interchange in the No-Build case.

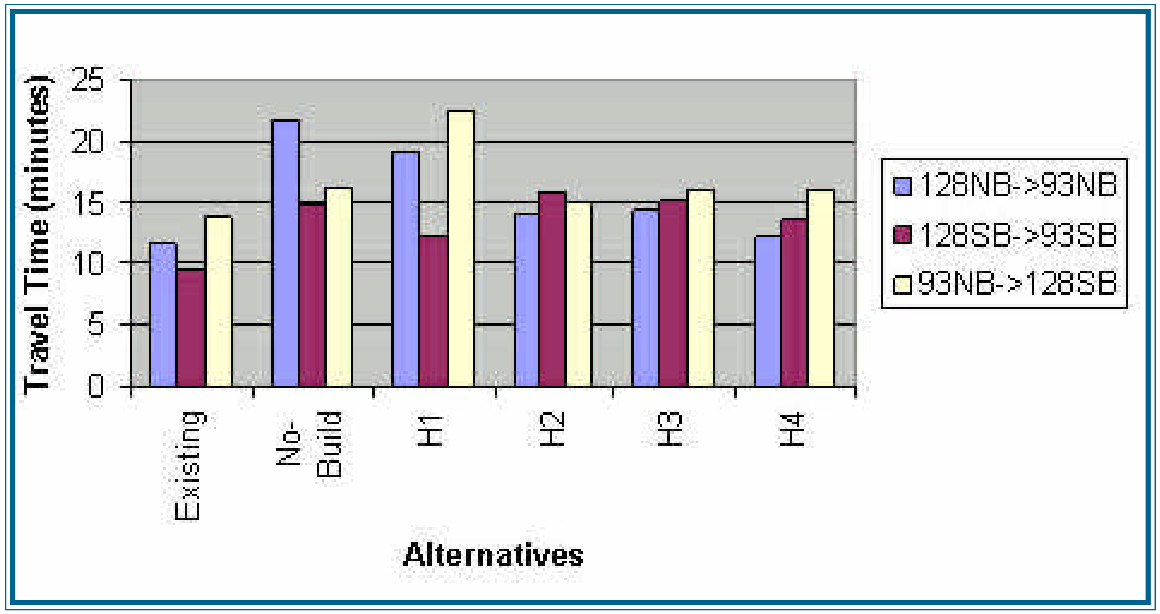
Note: EX = existing 2004
NB = No Build 2025

Travel Time

CORSIM was used to estimate the travel time through the project area (from Route 38 to North Avenue on Route 128 and from Montvale Avenue to Route 129 on I-93). There are 12 possible movements through the project area (four through-movements on I-93 and Route 128 and eight movements between the two expressways). The travel times for three major moves between Route 128 and I-93 are shown in Figure 3-5.

Average travel time for all 12 moves also improves substantially but with less variation among the alternatives. With no improvements, travel time through the interchange area would increase from 9 minutes in 2005 to 14 minutes (46 percent) for the 2025 No-Build in the morning peak hour and from 10 minutes (2005) to 18 minutes (84 percent) for the 2025 No-build in the afternoon peak hour. The alternatives reduce travel time by 15 to 20 percent compared to the No-Build in the morning peak hour and by 30 to 36 percent in the afternoon. (Owing to congestion on the two expressways, it is not possible to avoid increases compared to the existing condition in which less traffic is processed.) The shortest travel time in the morning would occur with H3-C; in the afternoon peak hour, H-4 has the shortest average travel time with H3-C a close second.

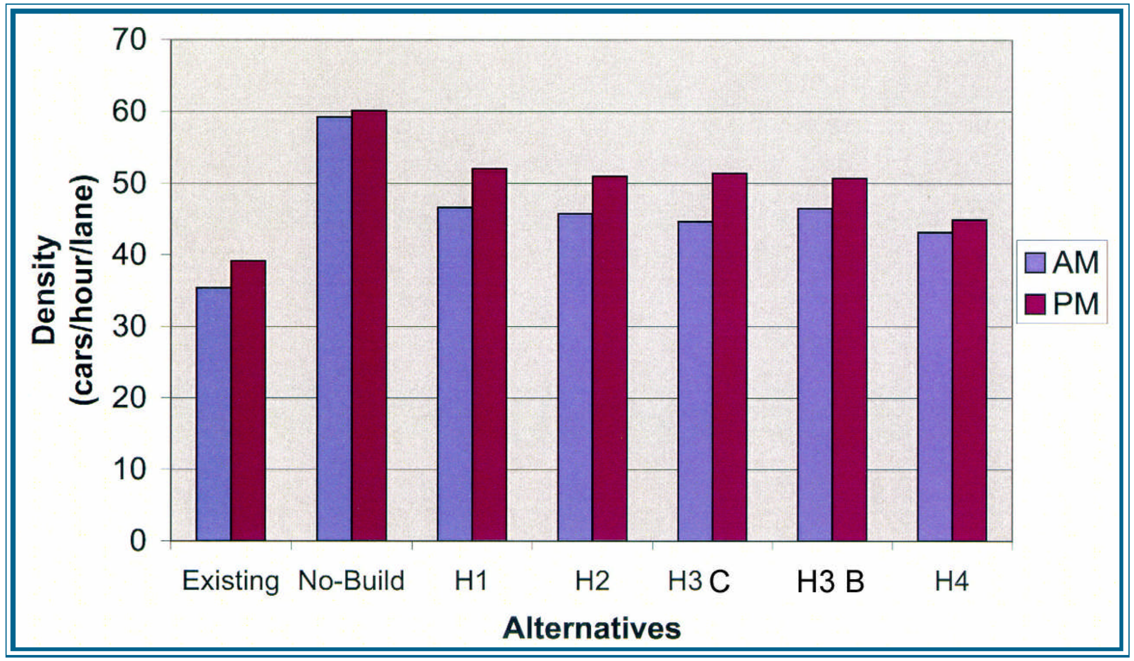
Figure 3-5: Travel Time Comparison of Three Major Moves (PM Peak Hour).



Congestion

Traffic density in vehicles per lane-mile is a measure of congestion. With the No-Build, density in the area modeled with CORSIM would increase 67 percent in the morning peak hour and 54 percent in the afternoon peak hour. The alternatives have densities higher than existing conditions but 21 to 27 percent lower than the No-Build in the morning peak hour and 13 to 25 percent lower than No-Build in the afternoon peak hour. H4 has the lowest densities, partly because it has more lanes than the other alternatives. (See Figure 3-6.)

Figure 3-6: Comparison of Alternatives, Level of Congestion.



Level of Service

Level of service is a concept that describes how well traffic flows. Level of service A (LOS A) is free-flowing traffic; LOS F is stop-and-go traffic in which traffic volumes exceed capacity. LOS D is less than ideal but generally considered acceptable in urban environments in situations with heavy traffic. HCS software was used to evaluate the level of service for each merge, diverge, and weave for each alternative. These results were summarized by counting the number of movements at each level of service. Results are shown in Figures 3-7 and 3-8 for the morning and afternoon peak hours, respectively. As volumes increase from the existing to 2025 No-Build, the number of movements operating at LOS E or F also increases. Alternative H1 does little to improve this situation in the morning peak hour, but does reduce the number of congested movements in the afternoon, primarily because it moves the northbound Route 128 lane drop to Exit 40. Alternative H3-C has no movements at LOS F and fewer at LOS E than the other alternatives. Alternative H-4 (which has additional movements because it adds collector-distributor roads) has three movements at LOS F in the morning peak hour and eight at LOS F in the afternoon peak hour. (Alternative H3-B was not included in this analysis because of the problems described above in the Summary of Traffic Operations; it was later refined to become H3-OS, which is analyzed in Chapter 4.)

Figure 3-7: Morning Peak Hour Level of Service

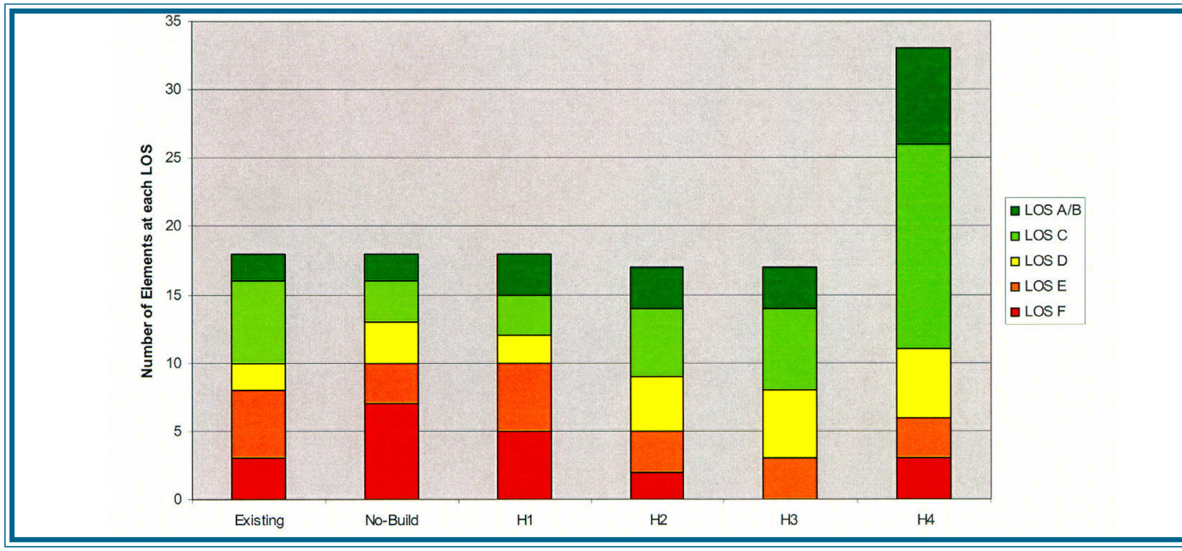
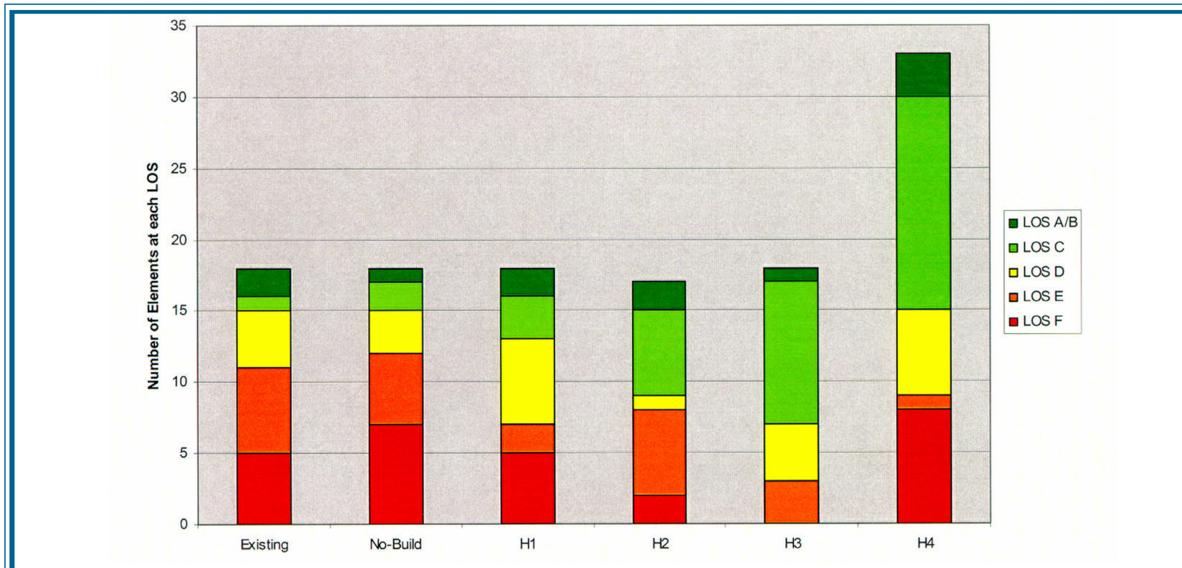


Figure 3-8: Afternoon Peak Hour Level of Service.



Driver Decisions

Alternatives H2 (on southbound Route 128) and H3-C (in both directions on Route 128) modify the existing sequence of decisions made by drivers who wish to leave Route 128 for I-93, because one off-ramp serves both directions of I-93, with a second decision shortly after one exits as to which direction on I-93 one wishes to go. In Alternative H3-B, the same off-ramp from northbound Route 128 to I-93 also serves movements to Washington Street. There is adequate distance for drivers to make these decisions in all cases. Alternative H4 makes more changes in the sequence of decisions, and these decisions are not intuitively obvious; for example, from southbound Route 128, one must use the collector-distributor road to reach I-93 northbound, but remain on the mainline to reach I-93 southbound; signage would be more complex for this alternative.

Safety Improvements

The very high crash rate described in Chapter 2 would be expected to become worse as traffic density increases in the 2025 No-Build. Speed differential is a summary measure of the speed differences between the fastest and slowest lanes in each part of the interchange area modeled with CORSIM; larger differences between lane speeds have the potential to increase crashes, so a reduction in this measure indicates a potential safety improvement. Table 3-2 summarizes the aggregate reduction in speed differentials throughout the modeled project area for each alternative. Alternative H4 performs best in this respect because it separates much of the slower traffic entering or leaving Route 128 onto C-D roads.

Alternatives H2 and H3 both reduce speed differentials, particularly in the morning because the removal of the southbound weave on Route 128 eliminates the existing situation in which higher speed through-traffic in the left lanes passes slow traffic in the weave areas.

As noted in Chapter 2, many crashes cluster in the existing weave areas and at the merge and diverge points. Table 3-2 shows the number of conflict areas removed or improved and the percentage of crashes associated with them. Alternative H3-C eliminates the weaves in which 37 percent of crashes currently occur and it improves the geometry of all the remaining merge and diverge movements. Alternative H2 improves only the northern half of the interchange. Alternative H4 improves all movements, but weaving movements remain for a reduced volume of local traffic using the existing loop ramps.

Table 3-2: Characteristics Related to Safety.

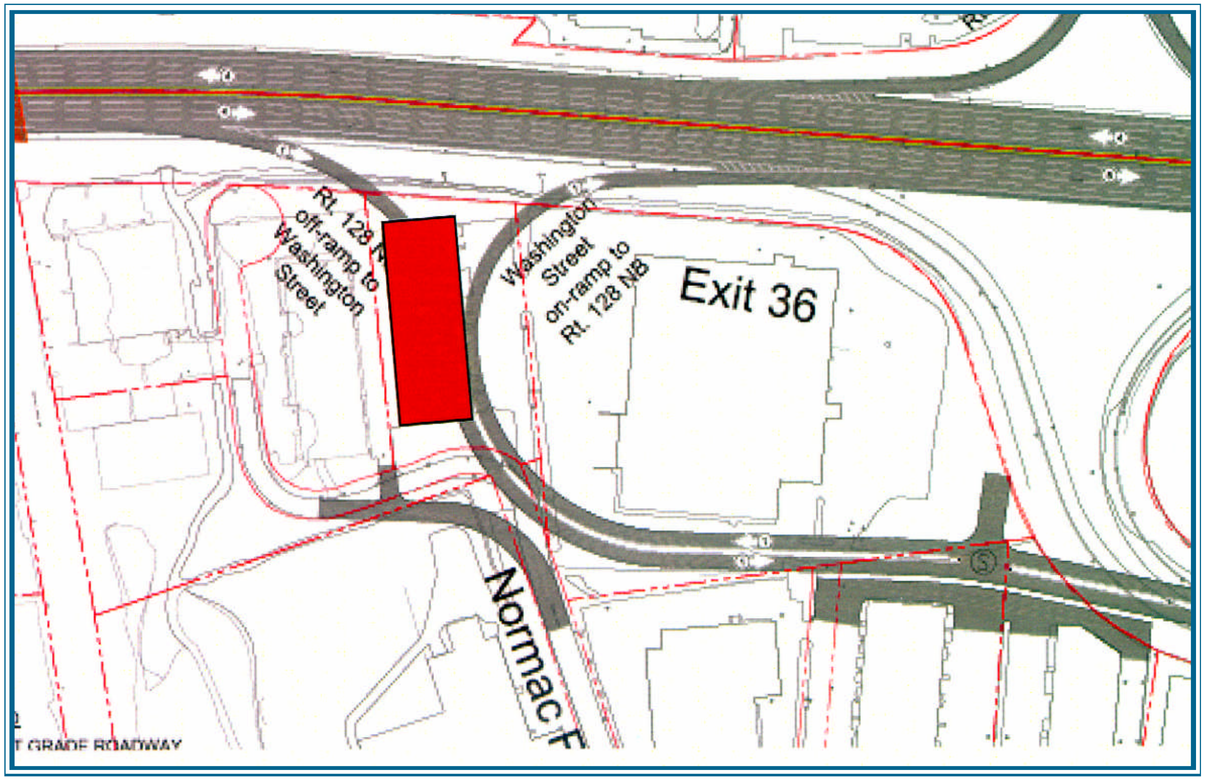
Alternative	No-Build	H1	H2	H3	H4
Percent Change in Speed Differential across lanes					
AM	base	-22%	-27%	-32%	-36%
PM	base	-12%	-25%	-25%	-39%
Conflict Areas Removed					
Number of areas	base	0	2	4	1
% in areas removed	base	0%	16%	37%	14%
Conflict Areas Improved					
Number of areas	base	7	13	17	20
Pct of crashes in areas improved		33%	40%	63%	86%

Takings

Alternative H3-C (H3-OR), which relocates the Washington Street ramps, would require an industrial building to be taken and strip takings to be made to provide access to the relocated ramps (see Figure 3-9). A childcare center and a materials distribution business would need to be relocated, and several parking lots would need modification but would not lose parking spaces. There are no business takings in H1, H2, H4, or the versions of H3 with split Washington Street ramps. There is some encroachment in the southwest quadrant on a wetland area adjacent to the interchange; the acquisition of this land or air rights above it could affect the amount of development permitted on the parcel of which it is part.

All alternatives avoid residential takings - no houses would be lost. Some small areas of land relatively far from the nearest residence would be required in Alternative H4 and the refined versions of H3, however. In the final versions of H3, an on-ramp to northbound I-93 passes within 77 to 104 feet of a house on South Street in Reading, and 1,740 to 4,700 square feet of property would need to be acquired from this residential lot and town land along the street (See Sections 4.1.2 and 4.1.3). The avoidance of most takings is accomplished by using 40 mph ramp design speeds, which are permitted under FHWA and MassHighway design guidelines with a design exception; a 50 mph design cannot be accommodated within the existing highway right-of-way.

Figure 3-9: Commercial Taking Associated with Related Washington Street Ramps (Alternatives H3-OR and H3-UR).



Noise

Noise was described by ITF members as a paramount issue for all three communities, which have residential neighborhoods abutting the highway layout line. These neighborhoods experience noise levels high enough to warrant noise barriers. Reading, Stoneham, and Woburn all have expressed the importance of getting noise barriers in place as soon as possible, potentially in advance of interchange construction. Although it is not possible within the scope of the planning study to quantify noise impacts, the team's noise experts, K.M.Chng Environmental Associates, Inc., assessed the alternatives qualitatively. They concluded that, for all alternatives, relatively small noise impacts would occur in some specific locations and may or may not be perceptible, while in alternatives H2, H3, and H4 other locations would receive a similarly small decrease in noise. During the environmental phase, quantitative noise modeling will be done, and specific recommendations will be made regarding noise barriers (See Section 4.1.2).

Visual Impacts

Visual impacts on adjacent neighborhoods are an important concern of all three communities. Alternatives H2, H3, and H4 all have one or more new semi-direct ramps that pass over I-93 and Route 128. The height of these fly-over ramps would be the same, approximately 25 feet above I-93 at their highest point. H3-B and H4 have two such ramps, while H3-C has a single flyover. These impacts would be perceptible only from vantage points close to the interchange. Computer renderings of the two versions of Alternative H3 are shown in the Executive Summary of this report.

Wetland Impacts

Figure 2-18 in Chapter 2 shows the existing wetlands within or adjacent to the existing interchange. Alternative H1 would have no direct wetland impacts. Alternatives H2, H3, and H4 would have direct impacts ranging from 6,000 square feet in H2 to 14,000 square feet in H3-C. For H4, the impact is approximately 12,000 square feet. H3-C (H3-US) had the largest impact because of its below grade ramp passing through four of the wetland areas. H3-B (H3-OS) passes over these wetlands at sufficient height to minimize impact and has direct impact only where columns occur in wetland areas. (These impact estimates were revised for the refined final alternatives as discussed in Section 4.1.)

Economic Impacts and Benefits

All alternatives have economic benefit by improving the dependability of the interchange and reducing delays. They also improve local access which improves the economic development potential of the business areas near the interchange. In addition to supporting the local and regional economy, all alternatives reduce the time spent in congestion. An analysis was performed that estimated the value of time lost due to delay, using delay estimates from the CORSIM model. Using the standard measure of the value of such time, which is assumed in value-of-time studies to be half the hourly rate of pay of people using the interchange, it is estimated that the cost of delay would triple in the next 20 years to more than $90 million per year, while the alternatives would reduce this future cost by $22 to $31 million. These estimates are not precise but do provide a perspective on the magnitude of annual delay and how it might be lessened by improving the interchange.

Constructability and Cost

The alternatives vary in both cost and difficulty of construction (see Figure 3-10). For the original four alternatives, estimated costs for the original alternatives would vary from $4 million for H1 to $94 million for H3-C and $213 million for H4. These costs were revised for the refined versions of the final alternatives as discussed in Chapter 4. H1 would be relatively easy to construct without disrupting traffic on Route 128; existing bridges over Route 128 would not require modification. Alternative H3-B, which involves ramps passing over the expressways on bridges would be moderately difficult, and H3-C with its below-grade ramp under both Route 128 and I-93 would be more difficult to construct than H3-B. H4 would be substantially more difficult to construct than the other alternatives.

Summary Evaluation

Figure 3-10 is a summary matrix comparing the four alternatives symbolically. In the matrix, green circles represent benefits and red squares represent impacts. The degree of impact or benefit is signified by an open, half-filled, or solid circle or square. It was decided not to assign a numerical score to each impact because different types of impacts are not directly comparable, and various evaluation criteria are viewed with different levels of importance by different stakeholders. Therefore comparing total scores would be misleading. As the matrix demonstrates, Alternative H1 does not have the same benefits as H3 and H4 but is relatively low in impact and cost. H2 also has fewer benefits than H3 and H4 because it addresses only half the interchange. H3 has the best safety improvements and more traffic operations benefits than H4, which is substantially more costly and difficult to construct. Given the overall benefits and impacts, it was decided to advance Alternative H3-C but also to consider refinements to H3-B that would attempt to solve its operational deficiencies. In addition, combinations of the relocated versus split Washington Street ramps would be considered with the H3 designs for the central interchange.

Because of its low cost and simplicity of construction, Alternative H1 was retained as a possible short-term improvement compatible with later construction of any of the versions of H3.

Figure 3-10: Summary Evaluation of Preliminary Alternatives.

Criteria	H1	H2	H3	H4
Highway Traffic	○	◒	●	◒
Safety	○	◒	●	●
Mobility	○	◒	◒	◒
Highway Design	○	◒	●	●
Takings				
Residential	●	●	●	□ sliver takings
Business	●	●	◪	●
Access				
Residential	◒	◒	◒	◒
Business	◒	◒	◒	◒
Local Traffic	○	○	○	○
Noise	□	○/□	○/□	○/□
Visual	▬	□	◪	◪
Wetlands (1000 sq.ft)	0	6	15	12
Econ/development	○	◒	●	◒
Difficulty of construction	□	◪	◪	■
Capital Cost	$4m	$49m	$94m+	$213m

Note: The final Alternatives H3-UR and H3-OR resulted in small takings of residential and commercial land, but no homes or businesses would be taken.

3.4.3 Further Development of Alternatives

The four basic alternatives were initially developed with single-lane ramps. Profiles were developed to confirm that 16.5-foot truck clearances could be provided with acceptable grades. In addition to H1, H2, and H4, two of the four possible variations of Alternative H3 were originally evaluated (H3-UR and H3-OS) with the use of CORSIM. Following the first round of evaluations and the public meeting in October 2006, attention focused on Alternative H3 as a full-build solution and H1 as a compatible interim solution. (H3-UR was the variation presented in detail at the public meeting because the split Washington Street ramp design had not been refined to perform satisfactorily at that time.) Two review meetings were held to present the designs to MassHighway and FHWA, and refinements were made in response to their comments, including the use of 2-lane ramps where possible. Finally, based on the evaluations, the split Washington Street ramps were selected in preference to the relocated ramps, and Alternatives H3-OS and H3-US were further refined. One refinement explored and presented at the March 2007 public meeting was a version of H3-OS in which the position of the ramps from Route 128 NB and SB to I-93 NB were "flipped," permitting a lower profile for the elevated ramp. Alternative H1 was also refined by the addition of an interim on-ramp from Cedar Street in Woburn to I-93 SB.

These variations are described in detail and evaluated in Chapter 4.

Table 3-3: Four Versions of Alternative H3.

	I-93/I-95 Interchange	
Washington St Access	**Both ramps over**	**128SB to 93SB under**
Relocated Ramps (Component 12)	**H3-OR** (formerly known as H3-A)	**H3-UR** (formerly known as H3-C)
Split ramps/ I-93 Connector (Component 13)	**H3-OS** (formerly known as H3-B)	**H3-US** (new combination)

3.5 Transit and Transportation Demand Management (TDM)

A consensus was developed early in the process that non-highway components need to be an integral part of the plan to improve the I-93/I-95 interchange. This is necessary both to meet the goal of improving regional mobility and also because highway improvements cannot by themselves accommodate all of the potential increase in demand for travel through the interchange area. Therefore, providing improved transit and TDM options for the traveling public reaches a large segment of the future demand by providing a choice of travel modes in addition to single-occupant vehicles, and these other modes reduce the number of vehicles attempting to use the interchange.

In addition, important environmental objectives are served by transit and TDM: they help to relieve local roadways of "spill-over" traffic diverted from the expressways by congestion and delay, and they reduce overall emissions of air pollutants and greenhouse gases (which contribute to climate change) as well as overall energy use.

Travel through the I-93/I-95 Interchange area originates largely from the north via the I-93 and I-95 corridors and to some extent from the south via I-93 to the Route 128 corridor. Route 128 and I-93 serve travel destinations in downtown Boston and the major employment centers in Woburn, Burlington, Lexington, and Waltham. Accordingly, the transit and TDM components were developed to serve these markets as well.

Transit and TDM in this context involves the following modes:

- Commuter rail to and from Boston, including reverse commuting from Boston.
- Bus service on Route 128 and feeder service from the communities surrounding the I-93/I-95 Interchange.
- High-occupancy private vehicles providing ridesharing and car-pooling to a broad range of destinations via the Route 128 and I-93 corridors.

Although transit and TDM cannot solve the interchange problem all by themselves, a combination of transit and ridesharing is an important part of the package of solutions to transportation needs in the interchange area.

Developing Transit and TDM Components

Three levels of transit and TDM improvements were considered and discussed with the ITF Transit/TDM Subcommittee.

1. Actions with low capital costs including services to encourage ridesharing and increased use of existing transit services, information programs, and work with employers to facilitate existing and new ridesharing programs. Most of these services are currently being provided by MassRIDES, the statewide travel options program funded by the Massachusetts Executive Office of Transportation.
2. Actions to increase existing MBTA rapid transit and commuter rail service and to provide new bus service; these actions require significant capital investment, primarily for new train sets and buses, and have on-going operating expenses.
3. Actions that have very high capital costs and/or require major changes in public travel patterns, such as regional high occupancy vehicle (HOV) lanes, toll facilities such as high occupancy toll (HOT) lanes, and major rapid transit and commuter rail extensions.

It was determined that the third level of improvements is outside the scope of the I-93/I-95 Interchange Study both because of their high potential costs and long time frames and the need to study them at a regional scale. However, the long range recommendations address the need for these studies. In general, the selection of transit and TDM components is intended to "push the envelope" but within realistic limits of cost.

The following components were selected for development and evaluation. Some will require further development and study in the environmental phase:

1. Implementing a fully online sign-up system for carpools in the area: MassRIDES is currently working to implement such a system, and has recently developed targeted mailings that include an individual's commute lengths and costs. Additional resources could help market the system and

increase its utilization.

2. Efforts to increase utilization of the Anderson Regional Transportation Center (RTC): A parking roundtable with TransitWorks, EOT, the MBTA and other stakeholders was convened to promote this goal. Two specific activities that could be included in the I-93/I-95 package of improvements are:
   2A. Creation of a formal park-and-ride program at the Anderson RTC. A formal park-and-ride program at Anderson would help reduce confusion among users about where and how ridesharing can be done at the facility, and increase the number of park-and-ride users there.
   2B. Improving access to the Anderson RTC: Improvements to pedestrian, bicycle, roadway, and transit access to the facility would help increase its utilization. Basic access improvements such as completing the sidewalk network within a ½ mile radius, and any specific recommendations from the parking roundtable, could be included. There was also consensus in the ITF that the pedestrian bridge designed as part of the Anderson RTC (but deferred because of budget limitations) should be built. This bridge would open up pedestrian access to business and residential destinations on the west side of the rail line.

3. Expanded ongoing marketing of transit services in the study area: This could include, for example, distribution of trial passes for MBTA commuter rail, MBTA bus, or Route 128 shuttle services. Short trial promotions could help demonstrate the convenience and attractiveness of services to current single-occupant vehicle commuters.

4. Expanded ongoing outreach and incentives for carpooling in the study area: MassRIDES currently conducts significant outreach efforts to employers in the vicinity of the study interchange and offers some financial incentives for vanpooling and (in small trial cases) carpooling. With additional resources, these efforts could be expanded. For example:
   - An carpool incentive program could be implemented in which commuters are offered monetary incentives for a certain period (e.g., 30 days) to try carpooling
   - The existing vanpool incentive program could be expanded to cover a greater portion of van lease costs each year (e.g., 2 months each year)
   - Additional marketing could be done to publicize the fact that MassRIDES services are free (misconceptions about fees are sometimes a barrier)

5. Expansions to peak-period "Route 128" shuttle service from Anderson RTC: Shuttle services along 128 could be re-established/expanded in several ways. The MetroNorth Shuttle service, which ran from the Anderson RTC to business areas in Woburn, Burlington, and Lexington during 2005-6 should be resumed as soon as possible and the following improvements should be made:
   - Adding new stops in existing service areas - Woburn, Burlington, and Lexington, as needed
   - Improving headways by providing separate buses to Burlington and Lexington meeting each train
   - Making the current on-demand service to Lexington a scheduled service and continuing these trips to Waltham
   - Providing connecting service to Reading Depot (by having certain trips originate in Reading before serving the Anderson RTC and Woburn/Burlington employers)

6. Addition of off-peak "Route 128" shuttle service: As outlined in the "I-93/I-95 Enhanced MetroNorth Bus Service" handout from the May 10, 2006, ITF meeting, off-peak service could be provided serving Waltham, Lexington, Burlington, Woburn, Anderson RTC, and a new Peabody park-and-ride (see Item 7 below); service could be provided on-demand with vans or taxis.

7. Establishment of a park-and-ride shuttle service from Peabody: As outlined in the "I-93/I-95 Enhanced MetroNorth Bus Service" handout from the May 10, 2006, ITF meeting, this could involve:
   - Establishing a new park-and-ride facility in Peabody at the I-95/Route 128 interchange
   - Providing peak-period shuttle service every 15 minutes to Woburn,

Burlington, and Lexington
- Providing off-peak service as part of the on-demand service described in Item 6

MBTA bus services from Lynn, Salem, and Peabody could also be expanded or modified to serve the new park-and-ride facility. It is also possible that a park-and-ride facility could be established on Route 1 north of the interchange, on the site of the existing Logan Express lot, but further study of this option is required.

8. Exploring cross-ticketing/fare payment arrangements on privately operated shuttle services: Such arrangements could allow MBTA pass-holders a discount on services such as the MetroNorth shuttle, to make the cost of MBTA-plus-shuttle trips more comparable to direct MBTA bus services such as Routes 350, 351, and 354.

9. Improved signage and traveler information to promote carpooling and transit: A range of activities can be considered, from solutions that can be implemented immediately to those requiring widespread adoption of recent or emerging technologies:
   9A. Installation of static signage on I-93 and I-95 promoting carpooling and transit: These would be particularly helpful on I-93 north of the Anderson RTC, and on I-95 north of Peabody (if the proposed Peabody park-and-ride service were implemented).
   9B. Installation of electronic signs or Variable Message Signs (VMS) on I-93 and I-95 promoting carpooling and transit: Same objective as 9A, but using electronic signs to display information about whether parking lots are full or simple promotional messages about transit and carpooling.
   9C. Use of real-time traffic, transit schedule, and parking information in signs, websites, cell phones, or other media: The addition of real-time information about traffic conditions, transit arrivals and departures, and parking availability would reduce uncertainty and allow travelers to make better-informed decisions. Current and emerging technologies can help disseminate this information in more effective ways.

10. Increased MBTA reverse-peak and local bus service: Improving headways on several existing MBTA bus routes could help shift the transit mode split to major employers. Two possible improvements include:
    - Improving reverse-peak service on Route 354 (which serves Boston, Woburn, and Burlington): Headways could be improved to 20 minutes to mimic the success of MBTA Routes 350 and 351.
    - Extending Route 132 (currently serving Malden, Melrose, and Stoneham) to serve the Reading commuter rail station, the Anderson RTC, and nearby employers in Woburn.

11. Enhanced MBTA commuter rail service on existing lines: Two potential improvements to the commuter rail system in the study area could be considered to attract ridership and divert drivers from the study interchange. These include:
    11A. Improvements in headways on the Lowell Line between Anderson RTC and Boston to create a shuttle-type service: Additional service could be introduced on this segment to reduce headways to 15 or 20 minutes in the peak period. This would make the Anderson RTC a more viable option for commuters from the north and east, and would also make reverse commuting from Boston to employment centers in Woburn, Burlington, and Lexington more viable (via the MetroNorth shuttle). Note: although it was not included in the initial package of improvements for evaluation, there is consensus in the ITF for maintenance of service at Mishawum Station; this would be more compatible with a shuttle service than on schedules originating in Lowell.
    11B. Additional service north of the Anderson RTC on the Lowell Line, the Haverhill Line, or both: Additional service could be provided in peak periods, shoulders of the peaks, during off-peak periods, or a combination. This would help improve the transit mode split in the I-93 corridor north of the interchange. This service could be coupled with the service increase considered in item 11A. Some trains

could be routed from the Haverhill Line through Anderson via the Wildcat Branch, as a few MBTA trains and the Amtrak Downeaster trains currently are routed.

Note: Over the course of this study - after the initial transit components were proposed in late summer 2006 - the MBTA implemented a substantial service increase on the Lowell commuter rail line, which began on October 30, 2006. This increase provided roughly two-thirds of the additional service that was proposed in the initial Transit Components 11A and 11B in this study. With this service increase in place, this study recommends that the remaining service increase be implemented, to achieve the additional mobility and environmental benefits that would come from full implementation of Transit Components 11A and 11B.

It is important to keep in mind that issues such as operational constraints (such as single-track rail segments and capacity at North Station), limited equipment availability, and budgetary constraints for both capital improvements and operating costs will need to be addressed for items 11A or 11B to be fully implemented. The costs to do this are included in the I-93/I-95 Interchange Study cost estimates.

Evaluation of Transit and TDM Components

The study team's transit consultant, TransSystems, worked with the CTPS to fully specify the package of components and to evaluate its effectiveness, using the CTPS regional transportation model. The model uses the estimated travel time and cost to allocate person-trips between all origins and destinations in the region to specific travel modes and routes. The mode share portion of the model is based on travel survey data as well as inputs on the start and end points of the specific transit services being evaluated, their headways (i.e., frequency of service and travel time), and assumed fares. As in the case of vehicular travel projections, ridership of the proposed services was estimated for the year 2025.

Future transit ridership was obtained directly from the regional model. TDM components were evaluated alongside the model by making manual changes to the model's trip tables based on published research on potential changes in travel mode from single occupant to multi-occupant vehicles in response to the types of markets and modes being evaluated.

For the transit and TDM components, two different markets were addressed: trips in the I-93 and Route 3 corridors oriented to Boston and the inner suburbs, and trips oriented to employment centers along Route 128, specifically Woburn, Lexington, and Burlington. (Waltham was not included in the target market because it was determined that only 7 percent of trips to Waltham employers come from locations that would potentially use the I-93/I-95 Interchange.) Inputs to the model runs and detailed results are presented in Appendix E.

As a first step, changes in travel modes in the target markets were projected for the No-Action case, which includes transit improvements that are currently planned to be implemented by 2025. As shown in Table 3-4, this will result in a small increase in the transit share and a small decrease in single-occupant and high-occupant vehicle shares of all trips.

Table 3-4: Existing and 2025 No-Build Mode Shares.

Mode	2005	2025 No-Action
Transit	5.4%	6.0%
Automobile	78.0%	76.7%
Single-Occupant Vehicle (SOV)	50.7%	50.6%
High-Occupancy Vehicle (HOV)	27.3%	26.1%
Non-Motorized	16.6%	17.3%

The results of the transit and TDM ridership projections were then combined. Because HOV and transit are to some extent in competition with each other, both "low shift" and high shift" scenarios were modeled. In the low-shift scenario, transit and TDM are treated as separate modes, and the resulting ridership of the two modes is simply added. The high-shift scenario compounds the effects of the two modes by assuming, for example, that the availability of HOV vanpools to the Anderson RTC induces some additional riders to use transit or that improved service to Boston induces additional ridesharing to Anderson. The results are shown in Table 3-5. ("Linked" transit trips count transfers as a single trip, e.g., traveling to Boston via bus and then commuter rail. All trips in the table are one-way, e.g., commuting to and from work is counted as two trips.)

In addition, the model runs tested the effect of implementing an HOV lane from Peabody to just east of the I-93/I-95 Interchange, which would provide a time saving for HOVs; with this advantage, daily ridership on a Peabody shuttle bus would increase from 200 to 400 in the low shift scenario and 600 in the high-shift. This time advantage is included in the high-shift scenario to show the maximum potential effect although the HOV is not being proposed as part of the transit/TDM package.

Table 3-5: Effectiveness of Transit and TDM Components.

Indicator	2025 No-Action (Base)	Change from 2025 No-Action			
		Transit Service Components	TDM Components	Transit + TDM (Low Shift)	Transit + TDM (High Shift)
Linked Transit Person-Trips	966,050	+830	+2,950	+3,530	+3,900
Anderson RTC Boardings	1,380	+450	+220	+600	+1,000
HOV Person-Trips	4,189,500	-140	+10,300	+10,700	+10,900
Vehicle-Trips	**9,800,000 (approx).**	**-650**	**-9,200**	**-9,900**	**-10,400**

The effectiveness of the transit and TDM package can be seen in the number of projected boardings at Anderson RTC. The additional boardings would use a substantial portion of Anderson's vacant parking spaces. The approximately 10,000 single-occupant vehicles removed from the region's roadways - most of them in the peak hours - would help to relieve congestion. The consensus of the ITF was that all components in the transit and TDM package (excluding HOV lanes between I-93 and the I-95 split in Peabody) should be advanced.

Transit and TDM are an important part of the overall solution for the interchange but they are not sufficient to solve the problem by themselves. CTPS prepared a "what if" analysis of what would be required to reduce traffic volumes at the interchange sufficiently to reduce peak hour traffic volumes at the interchange to Year 2000 levels, which would require shifting 4,300 person-trips to transit. The conclusion was that available commuter rail capacity on the Lowell, Haverhill, and Newburyport lines could handle approximately 80 percent of the shifted riders at full capacity, and parking at the stations would fall short by approximately 1,500 spaces. This analysis thus gives an idea of what could be necessary in the long run to further shift regional travel to transit.

The annualized capital and operating costs for the transit and TDM components were estimated at $5.6 million and $3.3 million, respectively. The cost analysis is described in detail in Chapter 4 and Appendix F.

4. RECOMMENDATIONS

The recommendations for improving the I-93/ I-95 Interchange respond to four key points and are based on an extensive process of problem analysis and alternatives development, all in close consultation with the Interchange Task Force. The ITF process was a collaborative effort in which all members were encouraged to ask questions and suggest options and the consultant team responded, leading to a general consensus on the two recommended alternatives to receive additional analysis and refinement in the next phase of study. **It should be emphasized that the ITF process led to the recommendation of the two specific variations of the "H3" highway alternative for further study, and that recommendations are intended to be a complete package; all recommendations are needed to fully address transportation in the project area.** Public involvement will continue during the environmental phase to achieve consensus on needed refinements and a preferred alternative.

Overall, four key points guided the development of recommendations.

1. As the region's busiest and most important system interchange, a major investment in infrastructure is warranted.

2. The solutions must be sensitive to the three host communities that closely border the interchange.

3. As a major part of the regional travel pattern, the solution must be comprehensive and include both highway and non-highway components as a single package to address overall mobility.

4. The open public process developed with the ITF must continue through project development and implementation.

Recommendations are shown in boldface in this chapter. The ten recommendations are also listed together on the last page of the Executive Summary.

4.1 Highways

A long-term solution and interim relief are both needed. Of the four major alternatives that resulted from an exhaustive screening process, Alternative H3, which replaces the northwest and southeast loop ramps with semi-direct ramps and extends the fourth lane of northbound Route 128, has great promise as the best long-term solution compatible with sensitivity to the surrounding communities. Alternative H1 is not a long-term solution, but it is compatible with Alternative H3 and can provide interim relief.

Alternative H3 has four possible variations depending on the design of the Washington Street ramps and the treatment of the two semi-direct connections that replace two loop ramps and thus remove weaves from the central interchange. In Chapter 3, the evaluation process found that the best design for Washington Street access uses split ramps and a connector road from northbound Route 128 to I-93. After design refinement, the split ramps with I-93 connector road showed superior traffic operations; this design also provided an improved profile on the ramp from northbound Route 128 to northbound I-93. The ITF reached consensus on this recommendation.

Recommendation 1:
The alternatives to be advanced for environmental study should both include split Washington Street ramps and a northbound Route 128 connector to I-93.

Selection of the split Washington Street ramps reduces the alternatives to H3-OS and H3-US. They are shown in plan and bird's-eye view in the Executive Summary to this report.

4.1.1 Final Evaluation of H3-OS and H3-US

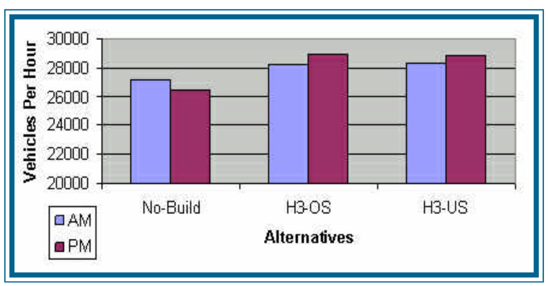
After the decision was made to use split Washington Street ramps instead of relocated ramps, the remaining two alternatives were refined in response to FHWA and MassHighway comments and received a final evaluation. The CORSIM model was used to test refinements during the design process. The principal refinement in both alternatives was to provide two lanes on the new and relocated ramps. Two lanes are desirable for the heavy traffic volumes the interchange must carry,

although the additional width adds to cost and increases the interchange footprint slightly. Providing two lanes on the ramp from southbound Route 128 to southbound I-93 and two to three lanes on the parallel connector road from northbound Route 128 to I-93 substantially improved traffic flow at these locations for both alternatives.

Traffic Operations

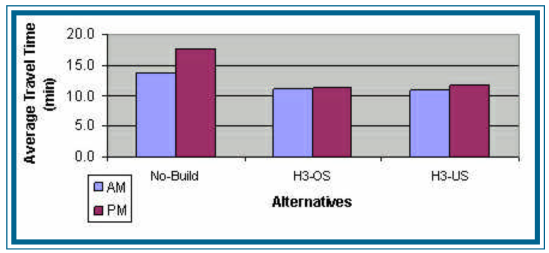
As noted in Chapter 3, in the future No-Build scenario, the interchange processes approximately 26,500 vehicles in the afternoon peak hour. H3-OS increases the number of vehicles that can be accommodated to 29,000 and H3-US was able to process 28,900, essentially the same volume (see Figure 4-1). The increase over the No-Build represents approximately 2,500 vehicles per hour that would use the expressways rather than an alternate route through the surrounding communities. There is a similar increase in vehicles processed in the morning peak hour.

Figure 4-1: Comparison of Alternatives: Total Exiting Volume.



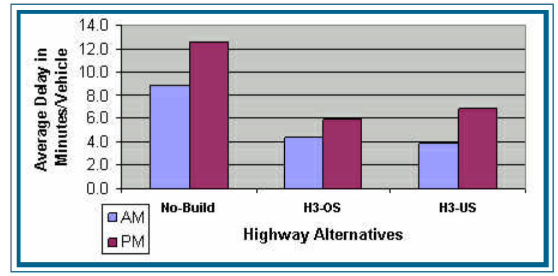
Travel Time: Average travel time through the interchange area (the average of the 12 possible routes through the interchange from Route 38 to North Avenue and Montvale Avenue to Route 129) would increase from 9 minutes in the morning and 10 minutes in the afternoon to a future No-Build average of 14 minutes (AM) and 18 minutes (PM). H3-OS and H3-US reduce the morning average time to 11.1 and 10.8 minutes respectively and the afternoon average time to 11.3 and 11.6 minutes respectively. (See Figure 4-2)

Figure 4-2: Comparison of Alternatives: Average Travel Time through the Interchange.



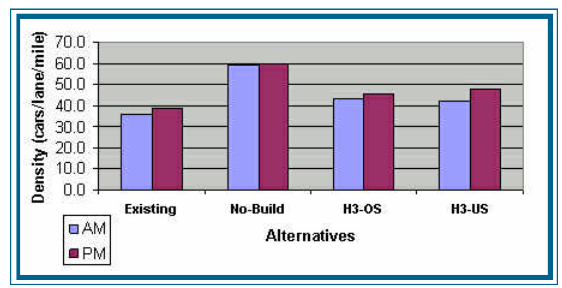
Delay: Average delay time increases substantially from the current 2 minutes in both peak hours to a future No-Build average of 9 minutes (AM and 13 minutes (PM). H3-OS and H3-US substantially reduce the future average delay to 4.4 and 3.9 minutes respectively and afternoon average delay to 5.9 and 6.8 minutes respectively. Thus, H3-US has a slight advantage in the morning and H3-OS has a bigger advantage in the afternoon. (See Figure 4-3)

Figure 4-3: Comparison of Alternatives: Average Delay through the Interchange (minutes/vehicle).



Congestion: Vehicle density is a measure of congestion. Currently peak hour density is in the range of 35 to 39 vehicles per lane per mile. In the future No-Build, the density of vehicles would jump to approximately 60 veh/lane/mile. In H3-OS and H3-US the density in the morning peak hour would be 43 veh/lane/mile in both alternatives, in the afternoon peak hour it would be approximately 46 veh/lane/mile in H3-OS and 48 veh/lane/mile in H3-US. (See Figure 4-4)

Figure 4-4: Level of Congestion.



Level of Service: The refined H3-OS and H3-US were also analyzed using the standard Highway Capacity Manual software and the traffic volumes from the CORSIM microsimulation model. Table 4-1 shows the level of service for the two final alternatives at each merge, diverge, and weave. The analysis shows that Levels of Service range from LOS B to LOS D with in nearly all instances. (The on-ramps from Washington Street are technically not merges because they enter as an added lane, and both ramps operate well.) These levels of service are substantially improved from the 2025 No-Build condition in which there are seven locations with LOS F in both morning and afternoon peaks; in the No-Build 56% of the locations are at LOS E or LOS F in the morning peak and 67% are at LOS E or F in the afternoon.

In Alternatives H3-OS and H3-US the following locations have levels of service lower than LOS D. The southbound diverge on Route 128 to Route 28 would operate at Level of Service E in both peak hours for both alternatives because the exiting volumes are slightly over the lower limit for LOS E. Although both alternatives slightly lengthen the weave on Route 128 between the I-93 southbound on-ramp and the Mishawum Road off-ramp, the volumes are relatively high and LOS E results in the morning peak hour. The morning peak hour volumes slightly exceed the capacity of the one-lane on-ramp from Mishawum Road to southbound Route 128, resulting in LOS F; this ramp works acceptably in the afternoon peak hour. Further improvements at these locations were not possible without takings and other impacts.

Alternative H3-OS and H3-US perform very similarly in almost all instances. In the morning, on southbound Route 128 between the on-ramp from Route 28 and the off-ramp to I-93, H3-OS is slightly over the boundary between LOS D and LOS E while H3-US is slightly under the limit; the alternatives differ by less than one percent in vehicle density.

Table 4-1: Comparison of Levels of Service, Based on 2025 Traffic Volumes from CORSIM.

Type/Location	AM Peak Hour		PM Peak Hour	
	H3-OS	H3-US	H3-OS	H3-US
I-95 (Rte 128) Northbound				
D: Exit to Mini C-D Road (Washington St, I-93)	B	B	C	C
F: Mini C-D Road downstream of I-95 Diverge	C	C	D	D
M: Washington Street On Ramp	C	C	C	C
M: I-93 SB On Ramp	B	B	C	C
W: Between 93 NB On Ramp & 28 SB Off Ramp	C	C	D	D
W: Between 28 SB On and 28 NB Off	C	C	C	C
M: 28 NB On Ramp	B	B	C	C
I-95 (Rte 128) Northbound Mini C-D Road				
D: Washington Street Off Ramp	C	C	D	D
I-95 (Rte 128) Southbound				
D: Exit 38 Off Ramp to Rte 28NB	E	E	E	E
W: Between 28 SB On and 93 NB & SB Off	E	D	D	D
M: On ramp from 93NB (Ramp B)	B	B	A	A
W: Between Ramp F & Mishawum Rd.	E	E	D	D
M: Mishawum Rd On ramp	F	F	D	D
I-93 Northbound				
D: Off ramp to 95NB (Ramp H)	D	D	D	D
D: Off Ramp to 95SB	C	C	C	C
M: On ramp from 95SB	B	C	C	C
M: On ramp from 95NB	C	C	C	C
I-93 Southbound				
D: Off ramp to 95SB (Ramp F)	D	D	C	C
D: Off ramp to 95NB (Ramp D)	C	C	C	C
M: On ramp from 95NB via CD Road	B	B	B	B
M: On ramp from 95SB	C	C	C	C

D = Ramp Diverge
M = Ramp Merge
W = Weaving Section
F = Freeway Segment

In summary, both alternatives substantially improve traffic operations compared to the future No-Build condition. The build alternatives are very close in performance with marginally better performance for H3-OS in several instances. As noted in Chapter 2, improvements to traffic operations in the I-93/I-95 interchange benefit the large volume of traffic that either moves from one interstate expressway to the other or simply passes through the study area on I-93 or Route 128. The problem at the interchange is not one of "downstream" congestion backing up through the interchange. While downstream sections will continue to experience varying levels of congestion, improving the I-93/I-95 Interchange will benefit every trip that passes through it (see the document "Benefits of Reducing Traffic Congestion" on the study web site).

Safety

Both H3-OS and H3-US improve safety throughout the interchange by eliminating weaves and improving geometry to reduce conflicts between vehicles that contribute to crashes. The speed differentials between fast- and slow-moving lanes would also be reduced by a similar amount in both alternatives, compared to the No-Build, and this reduction would also contribute to safety (for more information, see the documents "Safety Issues Summary" and "Safety Analysis" on the study web site).

Wetland Impacts

The two-lane ramps in both build alternatives would increase the interchange footprint and increase wetland impact, compared to the unrefined versions evaluated in Chapter 3. With the use of the split Washington Street ramps, both H3-OS and H3-US have the same impact on the wetland in the southwest quadrant of the interchange where a ramp would pass over the wetland at a height ranging from 16 to 30 feet, which is high enough to allow sunlight to reach all of the wetland. Within the interchange, the below-grade ramp of H3-US would have a greater wetland impact than the corresponding elevated ramp in H3-OS, which would shadow but not occupy wetland areas. (Preliminary design is necessary to estimate the potential impacts of the piers supporting elevated ramps, so this impact is not included.) The resulting wetland impacts are shown in Table 4-2.

It is noted that extending the fourth lane on northbound Route 128 to Exit 40 in Wakefield will require work within the buffer area of vegetated wetlands between Parker Road and North Avenue, but no wetland alteration is anticipated.

Takings

The refined H3-OS and H3-US widen the interchange footprint and require the acquisition of only portions of property in the northeast and southwest quadrants; however, no residences or businesses would need to be acquired. The property needed in the northeast is a triangle of approximately 1,740 square feet in H3-OS and 4,700 square feet in H3-US. Approximately half of the taking would be from a residential lot on South Street and the remainder from town-owned land next to South Street. The ramp which requires the property would be 104 feet from the nearest residence in H3-OS and 77 feet in H3-US. The taking in the southwest quadrant is of undeveloped wetland, but it could affect the development capacity of the parcel of which it is part.

Visual and Noise Impact

Visual and noise impacts are of great concern to the adjacent neighborhoods. As discussed in Chapter 3, the development of alternatives considered many preliminary components but the only geometrically feasible alternatives for eliminating interchange weaves without major property takings have ramps entering I-93 in the northeast and southwest quadrants. The two-lane ramps make the edge of the interchange slightly closer to the adjacent neighborhoods. H3-US, whose closest ramp is below grade, would have less visual impact to the South Street area in Reading than H3-OS. Figure 4-5 shows ground level views of H3-OS and H3-US from the edge of the nearest neighborhood in Stoneham, Woburn, and Reading.

As discussed in Chapter 3, the changes in noise at locations along the edge of the adjacent neighborhoods would be at a level that may or may not be perceptible. Computer noise modeling is necessary to compare the effects of H3-OS and H3-US; this modeling will take place in the environmental phase. Noise barriers will also be evaluated using the computer model. In connection with the extension of the northbound fourth lane on Route 128, the noise analysis and consideration of noise barriers will include the stretch of Route 128 to Exit 40 in Wakefield (as noted in Recommendation 4 below, noise barriers should be constructed as early as feasible).

Figure 4-5: Street-Level Views of Alternatives H3-OS and H3-US.

H3-OS from Constitution Road, Stoneham.

H3-US from Constitution Road, Stoneham.

Figure 4-5: Street-Level Views of Alternatives H3-OS and H3-US. (continued)

H3-OS from Richard Circle, Woburn.

H3-US from Richard Circle, Woburn.

Figure 4-5: Street-Level Views of Alternatives H3-OS and H3-US. (continued)

H3-OS from Walnut Street, Reading.

H3-US from Walnut Street, Reading.

4.1.2 I-93/I-95 Interchange Ramps: Both Ramps Over or One Under?

Table 4-2 summarizes the evaluation of the final alternatives. The choice of a double flyover versus putting one ramp under and one ramp over depends on a number of factors. The double fly-over design (H3-OS) will be simpler to construct than the H3-US design in which one ramp goes under both I-93 and Route 128 and the other ramp goes over them. Overpass construction would be less costly, shorter, and less disruptive to the continuous operation of both expressways than the construction of a depressed ramp with short tunnel segments under both highways in H3-US. The depressed ramp will also be more costly than the corresponding overpass connection because the profile of the fly-under ramp is as much as 50 feet below the ground surface where it goes under I93, and potentially 10 to 15 feet into the groundwater, requiring waterproofing, pumped drainage, and foundations to counteract buoyancy. One constructability issue with the double flyover in H3-OS is that its overpasses cross above the existing I-93 bridge, while in H3-US the single flyover is to one side of the existing bridge where it will be simpler to construct. However, on balance the construction of H3-OS will be less difficult than H3-US.

Table 4-2: Summary Evaluation of Alternatives H3-OS and H3-US.

Both New Interchange Ramps Over I-93 and Rte 128	One New Ramp Under and One Ramp Over I-93 /Rte 128
H3-OS	**H3-US**
▪ Traffic on 128, I-93, and Washington St. improved	▪ Traffic on 128, I-93, and Washington St. improved
▪ Limited takings in NE quadrant	▪ Limited takings in NE quadrant
▪ Small Noise impacts	▪ Slightly lower noise impact (difference may not be perceptible)
▪ Visual Impact of two flyovers approx 25 feet above I-93	▪ Visual impact of single flyover (same height) is less
▪ Wetland filled 2,940 SF ▪ Wetland under structure 31,300SF	▪ Wetland filled 11,400 SF ▪ Wetland under structure 26,400SF
▪ Moderate construction difficulty with overpasses above I-93 bridge	▪ Greater construction difficulty with deep boat section and short tunnels under 128 and I-93; overpass not above I-93 bridge.
▪ No groundwater issues	▪ Groundwater issues due to deep boat section ramp
▪ Moderate cost ($160 million incl. $21 million for noise barriers)	▪ Higher cost ($249 million incl. $21 million for noise barriers)
Both alternatives: ▪ Use split Washington St ramps and I-93 connector, and rebuild Washington St bridge ▪ Improve traffic operations in the interchange and avoid cascading backups ▪ Improve safety; 5 major weaves eliminated (including Washington St ramps to I-93) ▪ Use 40 mph ramp design that avoids takings but needs FHWA approval in Environmental phase	

On the other hand, the single flyover ramp in H3-US will have less visual impact on adjoining neighborhoods in Reading and Woburn than the double flyover in H3-OS, although both designs are of the same height. Additional noise impacts due to the interchange modifications are expected to be minor, but because of the existing high level of traffic noise, noise barriers are likely to be warranted. The depressed ramp in H3-US will offer some noise attenuation compared to its elevated counterpart in H3-OS, but noise modeling is needed to determine whether this difference will be perceptible. There would be a larger area of wetland under structure in the double flyover design, but much of this would be under ramps high enough to admit sunlight so that the affected wetland would retain some resource value. For the H3-US alternative with a depressed ramp, a larger area of wetlands would be displaced and a similar amount shadowed.

After extensive discussion in the Interchange Task Force, it was concluded that both alternatives are essentially equal in improvements to traffic operations and safety. However, a number of the differences between the alternatives in their impacts, constructability, and cost cannot be accurately determined with the level of engineering design and environmental analysis that is possible within the current planning study.

Recommendation 2:
Alternatives H3-OS and H3-US should be given equal scrutiny to explore construction sequences, refine costs, and establish comparative noise, visual, and wetland impacts in detail. The appropriate place to answer these remaining questions and select a final highway alternative is in the environmental study which must follow the planning study.

The environmental phase of project development is described in Section 4.3, below.

4.1.3 Remaining Issues to be Addressed

The following issues should be fully addressed in the environmental/preliminary design phase of project development:

- Partial property takings in Reading, both alternatives.
  - H3-US: 4,700 SF; 77 feet from nearest home, below grade.
  - H3-OS: 1,741 SF;104 feet from same home, above grade.
- Wetland impacts.
  - Need to find least environmental damaging practicable alternative (LEDPA) for federal permitting under the Clean Water Act, Section 404.
  - Structure above wetland area in Woburn, both alternatives, high enough for minimum disturbance to wetland resource.
  - Extent of fill in both alternatives to be monitored as designs are refined.
- Development of design.
  - Could swap on-ramps to I-93 north in Reading in H3-OS to lower the elevated ramp; this moves a surface ramp to 63 feet from nearest home.
  - Next phase: need to develop cross-sections and side slopes- unlikely to result in takings in NW and SE quadrants; will refine property takings in northeast quadrant.
  - Next phase: need to develop subsurface design, particularly H3-US, with respect to groundwater.

- Constructability.
  - Next phase: need to refine designs, develop conceptual staging plans.
  - Design development requires subsurface data collection, particularly for H3-US.
- Noise barriers.
  - Allowance for barriers included in cost ($21 million).
  - Barriers may involve some takings to be effective.
- Design approvals.
  - Next phase: need to document need for 40 mph ramp design speed.
  - Requires FHWA and MassHighway approval of design exception.

4.1.4 Further Refinement of Highway Alternatives

The consensus within the Interchange Task Force to recommend that both H3-OS and H3-US should be advanced to the environmental phase was based in part on the understanding that further refinements would be studied during engineering development. An example of such a refinement, which may reduce impacts, is a variant of H3-OS that changes the order in which the ramps from northbound and southbound Route 128 merge with northbound I-93. This "flipped ramp" variant allows the profile of the semi-direct ramp from northbound Route 128 to be lower, reducing impacts on the South Street neighborhood in Reading. This variation appears to shift the alignment of the ramps approximately 40 feet further east; however, the tradeoff compared to a higher ramp further away appears to be worthwhile in terms of neighborhood impacts. Further engineering is needed to confirm the alignments and profiles of the two variants.

Recommendation 3:
During the environmental phase, further engineering should be done to explore variations that can improve the two alternatives and reduce their impact.

Figure 4-6: Two Variants of Alternative H3-OS; version with flipped ramps is on the right.

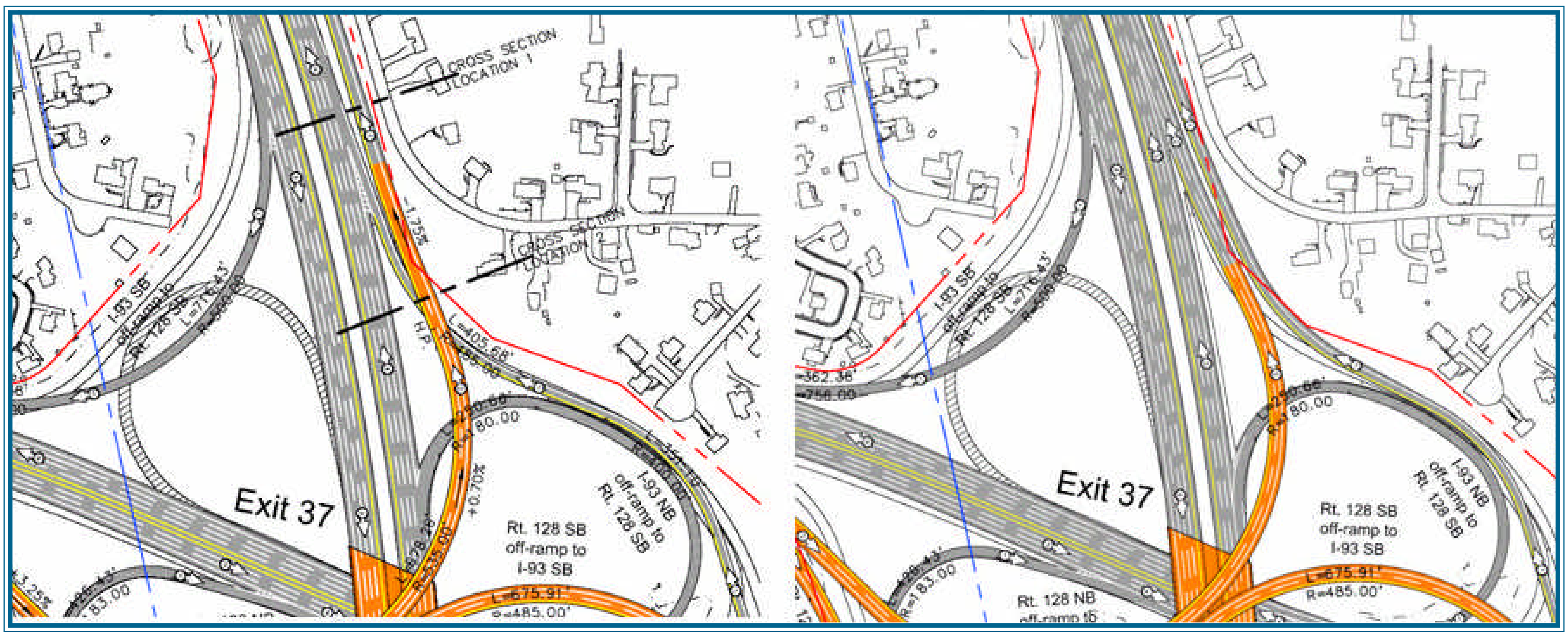
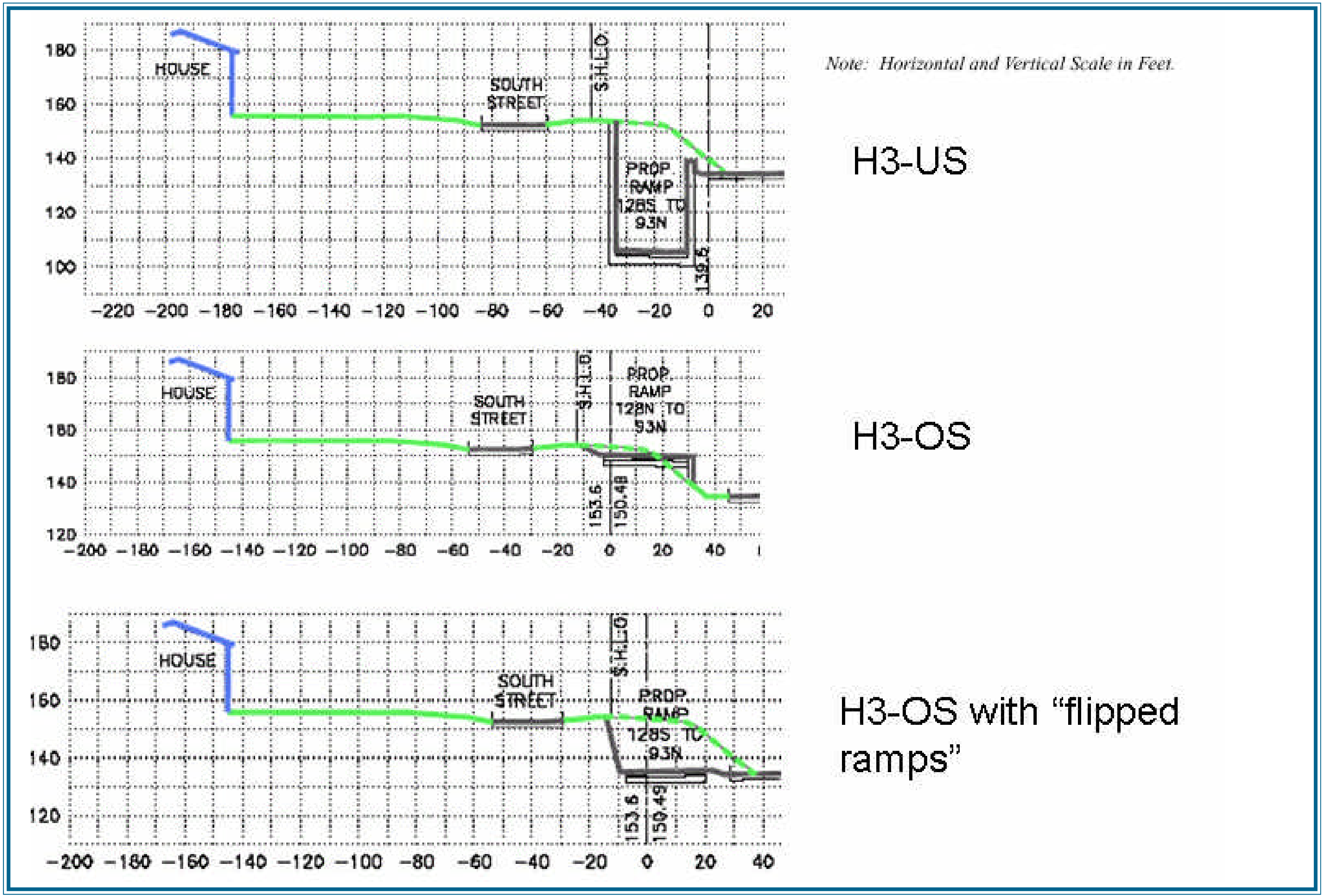


Figure 4-7: Comparative Cross-Sections at South Street: H3-OS Variants and H3-US.



4.1.5 Interim Improvements

Both H3 alternatives would have an interim phase of improvements (which are similar to the alternative designated H1). The interim improvements would be relatively simple to construct and would relieve the northbound bottleneck on Route 128 by extending the fourth lane to Exit 40 (Route 129). The interim package would also improve the southbound weave by beginning the fourth lane on southbound Route 128 at the Route 28 on-ramp. This additional lane on Route 128 SB would allow through-traffic to get by the weaving traffic in the interchange and reduce the cascading back-ups in the existing cloverleaf until a permanent solution can be put in place.

Although all bridges over Route 128 are wide enough to accommodate the additional northbound lane from I-93 to Route 129 and the auxiliary southbound lane from Route 28 through the I-93/I-95 Interchange, the interim package will involve some additional pavement and will attract some additional traffic to Route 128. It therefore needs full environmental review of air quality, local traffic, noise, and stormwater management.

Noise barriers may be warranted for segments of Route 128 where existing or resulting noise levels meet MassHighway noise abatement criteria. There may also be an opportunity to build noise barriers before construction of the full I-93/I-95 Interchange improvements at other locations at the interchange that currently meet the criteria for the "Type II" noise abatement program and which would not require noise barrier relocation during construction of the full improvements. This would both bring earlier relief for residential areas that currently qualify for noise abatement and also mitigate construction noise during the permanent modification of the interchange.

During the ITF discussions, Cummings Properties suggested the addition of an on-ramp to I-93 southbound from Cedar Street in Woburn. Preliminary analysis of this ramp suggests that it is a worthwhile interim measure that would be low in cost and would provide relief to the congested intersections on Washington Street both north and south of Route 128 as well as Montvale Avenue between Washington Street and the I-93 ramps. It would provide a useful measure to manage traffic during reconstruction of the I-93/I-95 Interchange and Washington Street ramps. The Cedar Street ramp (Figure 4-8) should therefore be further developed in the environmental phase. This ramp would be included in the interim improvements package and later removed from service during the final stages of I-93/I-95 interchange reconstruction.

Recommendation 4.
Extension of the fourth lane on Route 128 northbound to Exit 40 (Route 129), and on Route 128 southbound from Exit 38 (Route 28) should be implemented as an interim improvement, along with an on-ramp from Cedar Street in Woburn to southbound I-93. Where warranted by MassHighway noise abatement guidelines, noise barriers should be constructed as part of the interim improvements, adjacent to the added lanes on Route 128 and also at other locations around the I-93/I-95 Interchange where barrier relocation would not be required during construction of full improvements.

Figure 4-8: Cedar Street Ramp.

4.1.6 Potential Highway Costs

The conceptual cost estimates for highway improvements are $139 million for H3-OS and $228 million for H3-US. These costs are based on quantities of at-grade, above grade, and below grade construction and current unit prices. The higher cost of H3-US is due to the construction of the alternative's deep boat sections and short tunnel underpasses.

The cost of the interim improvement package alone is estimated at $4 million, excluding needed noise barriers. Most of the interim improvements become part of the final improvements, and the cost of the interim package is included in the cost of the full reconstruction alternatives.

In addition to the costs for highway improvements, noise barriers will be required in many locations. The costs of the anticipated barriers, some of which could be built as part of the interim improvement package, would be approximately $21 million, making the total costs for interim improvements, noise barriers, and interchange reconstruction $160 million for H3-OS and $249 million for H3-US.

Table 4-3: Cost of Highway Alternatives.

	H3-OS	H3-US
Interim Improvements	$4 million	$4 million
Permanent Improvements	$135 million	$224 million (incl interim)
Subtotal, Highway Improvements	$139 million	$228 million
Noise Barriers	$21 million	$21 million
Total	**$160 million**	**$249 million**

Note: Costs are in current (2006) dollars.

For more information, see Appendix D.

4.2 Transit and Transportation Demand Management

As discussed in Chapter 3, the comprehensive package of transit improvements and transportation demand management (TDM) measures is an effective way to increase regional mobility and contribute to reducing congestion at the I-93/I-95 Interchange, removing an estimated 10,000 vehicle trips per day from the expressways. For these reasons, and because it is also a first step toward conserving energy and reducing greenhouse gas emissions, the full set of transit and TDM measures should be part of the overall package of I-93/I-95 improvements.

Recommendation 5.
All transit and TDM improvements described in Chapter 3 should be included with the recommended highway improvements in an integrated multi-modal package of actions to be further developed and analyzed in the environmental phase.

4.2.1 Transit and TDM Costs

The following is a summary of the conceptual cost estimates for the transit and TDM components developed for the study. Note that costs have not been estimated for several components because they are either currently being explored in separate efforts by others or they require further study. See Appendix F for more detail on capital and operating costs, including annualized estimates.

Table 4-4: Conceptual Capital Costs of Recommended Transit and TDM Improvements.

Transit Component	Conceptual Capital Cost (2006$)	TDM Component	Conceptual Capital Cost (2006$)
5. Expanded Anderson shuttle service	$0	1. On-line carpool sign-up	$0
6. Off-peak Anderson shuttle service	$0	2A. Formal Park-and-Ride program at Anderson	$0
7. Park-and-Ride shuttle from Peabody	$1.8 million	2B. Improved pedestrian/ vehicle access to Anderson	$2 million
10. Increased MBTA reverse-peak, local bus service	$1.1 million	3. Expanded marketing of transit	$0
11A. Frequent commuter rail - Anderson to Boston	$14 million	4. Expanded outreach and incentives for carpooling	$0
11B. Frequent commuter rail - Lowell and Haverhill to Boston	$0	8. Cross-ticketing/fare payment on private shuttles	$0
		9. Improved signage and information	$1.3 million
TRANSIT TOTAL	**$16.9 million**	**TDM TOTAL**	**$3.3 million**

Table 4-5: Conceptual New First Year Operating Costs of Recommended Transit and TDM Improvements.

Transit Component	Conceptual Operating Cost (2006$)	TDM Component	Conceptual Operating Cost (2006$)
5. Expanded Anderson shuttle service	$1.2 million	1. On-line carpool sign-up	$0 (Underway)
6. Off-peak Anderson shuttle service	$300,000	2A. Formal Park-and-Ride program at Anderson	$0 (Underway)
7. Park-and-Ride shuttle from Peabody	$800,000	2B. Improved pedestrian/ vehicle access to Anderson	Minimal
10. Increased MBTA reverse-peak, local bus service	$600,000	3. Expanded marketing of transit	$700,000
11A. Frequent commuter rail - Anderson to Boston	$1.0 million	4. Expanded outreach and incentives for carpooling	$2.2 million
11B. Frequent commuter rail - Lowell and Haverhill to Boston	$200,000	8. Cross-ticketing/fare payment on private shuttles	Requires further study
		9. Improved signage and information	$50,000
TRANSIT TOTAL	**$4.1 million**	**TDM TOTAL**	**Approx. $3 million**

For more information, see Appendix F.

4.3 Recommendations for Future Phases

Project development for highway, transit, and TDM projects differ in detail, but have several key aspects in common:

1. Alternatives must be developed sufficiently for complete environmental analysis.
2. Final decisions are made only after a "hard look" at all relevant issues under both the applicable state and federal laws.
3. The preferred alternative is further developed to a preliminary design level for highways and transit infrastructure, and operations plans are developed for transit services.
4. Capital projects are added to the regional and state long range transportation plans and the 5-year Transportation Improvement Program (TIP) for funding.
5. Final design of highway and transit infrastructure.
6. Construction of infrastructure and procurement of capital items such as trainsets and buses.

Major transportation projects require environmental analysis under the Massachusetts Environmental Policy Act (MEPA) and the federal National Environmental Policy Act (NEPA). This involves coordination with Federal Highway Administration (FHWA) and the MEPA unit in the Executive Office of Energy and Environmental Affairs (EOEEA), resulting in a combined Environmental Impact Statement/Report. The conclusion of this process is the issuance of a certificate by the Secretary of EOEEA and a federal Record of Decision, both of which are based on consideration of the environmental analysis, including public and agency comments. MEPA and NEPA are similar, except that the federal Environmental Impact Statement includes social and economic analysis as well as environmental and cultural impact analyses. The federal and state environmental processes result in both a final decision as to the proposed action and also a set of binding commitments to mitigate unavoidable impacts.

The MEPA regulations (301 CMR 11.00) provide for multiple agencies to act as proponents for complex multi-modal projects. The Executive Office of Transportation (EOT) would be the lead agency working in close coordination with the MBTA and MassHighway. EOT would coordinate with FHWA regarding the federal NEPA process. A single Draft EIS/R would result, a joint state/federal public hearing would be held, and a joint Final EIS/R would be prepared.

MEPA regulations also provide for project implementation in more than one phase. The interim highway recommendations of the I-93/I-93 Interchange Study and early phasing of certain transit services and TDM actions can thus be addressed in a single coordinated environmental process that is more efficient than separate environmental documents for interim and long-term actions and may reduce the time needed to begin interim improvements.

In situations that involve more than one proponent agency and phased implementation, the Massachusetts Secretary of the Executive Office of Energy and Environmental Affairs (EOEEA) generally requires a Citizens Advisory Committee (CAC) to be appointed to work with the proponent agencies during the environmental process. It would be natural for the existing I-93/I-95 Interchange Task Force to serve as the core of the CAC, with members added as necessary to represent environmental and other interests deemed appropriate by the Secretary of EOEEA.

Recommendation 6.
The highway and non-highway recommendations of the I-93/I-95 Interchange Study have been conceived, evaluated, and discussed with the Interchange Task Force as a multi-modal integrated package of improvements. Therefore, this package, including interim improvements, should be developed and evaluated in a single environmental study, resulting in an Environmental Impact Report and Statement that addresses the entire package.

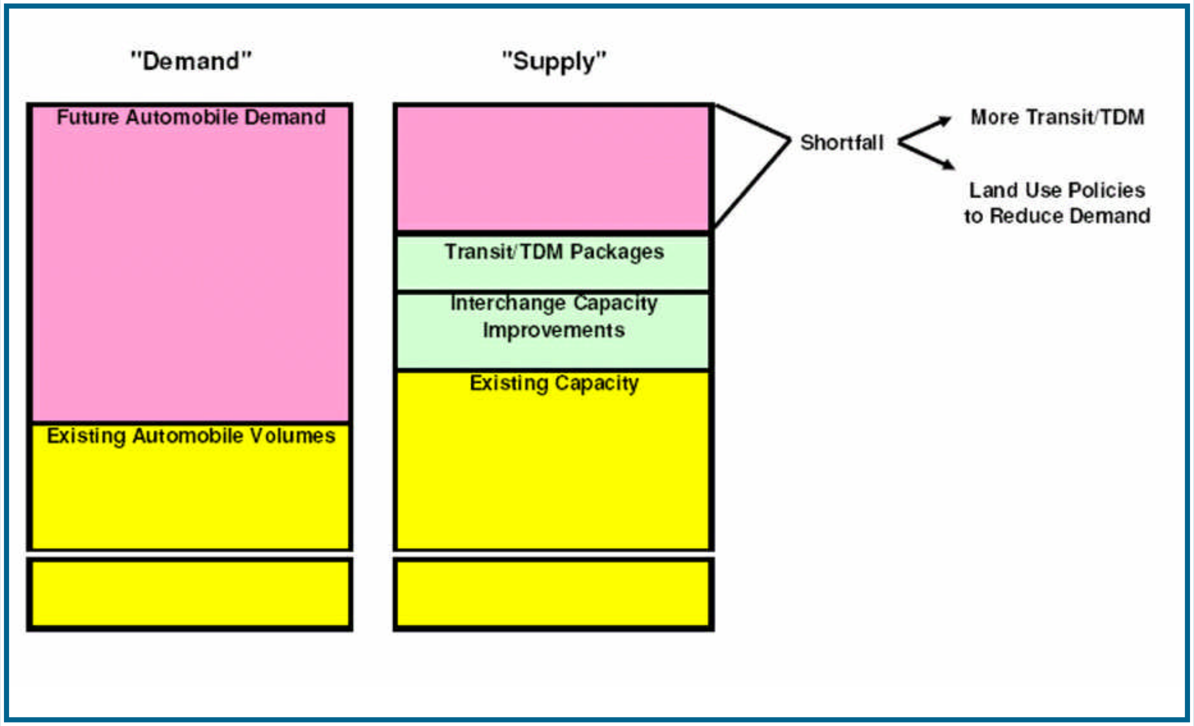
Recommendation 7.
The environmental studies should be based on a continued open process of public involvement and should be prepared in coordination with an ongoing Citizens Advisory Committee incorporating the members and interests of the I-93/ I-95 Interchange Task Force and the affected communities. Minimizing takings, noise, and visual impacts are essential to maintaining community support.

4.4 Long-Range Recommendations: Managing Corridor Congestion

It is a fundamental fact that future travel demand will exceed the capacity of Route 128 and I-93 to accommodate it in peak hours, with the result that congested peak hours will become steadily longer and traffic will continue to divert to local roadways.

The I-93/I-95 Interchange Study recommendations for interchange improvements and transit/TDM measures will be a significant improvement, particularly for trips using the interchange between Route 128 and I-93 and transit trips into Boston. However, adding more capacity on the 8-lane sections of Route 128 and I-93 is not planned even the long run, and is unlikely to happen because of its environmental impacts. Therefore, there will be a future gap between demand for travel in the peak hour and capacity to carry that demand. Figure 4-9 illustrates this situation.

Figure 4-9: Additional Approaches to Address Corridor Congestion.



Three types of longer range improvements should be considered as part of regional transportation planning. It is intended that these improvements should be studied in the near term but outside the environmental process for the highway, transit, and TDM recommendations of the I-93/I-95 Interchange Study.

- Intelligent Transportation System Improvements.
  - Information systems to respond to crashes and other incidents.
  - Regulation of the rate vehicles enter the system.
  - Variable speed limits to optimize traffic flow.
- Additional long-range measures to increase transit use and high occupancy vehicle (HOV) use.
  - Additional commuter rail and rapid transit parking.
  - Expanded bus service in the Route 128 corridor.
  - HOV lanes in the I-93 and Route 128 corridors.
- Land use policies that help to reduce overall demand in the I-93 and Route 128 corridors, beginning with the MetroFuture recommendations of MAPC.

4.4.1 Intelligent Transportation Systems (ITS)

ITS refers to a set of techniques to improve transportation systems and mobility through information processing and information availability in real-time. Examples range from variable message boards that alert motorists to crashes and other incidents ahead on the highway to computer algorithms that calculate optimum traffic speeds based on remote sensors.

These systems have the potential to make traffic flow and transit more efficient, and they should thus be part of the regional transportation system. Both short-term improvements, like signage, and long-term improvements like variable speed limits and ramp metering should be considered and implemented where appropriate.

Assessing the applicability of specific ITS improvements should be the subject of a coordinated study by EOT. It should be kept in mind though, that the motoring public is part of the intelligent transportation system. This means that public acceptance and understanding of how to utilize the system is necessary.

Information Systems

- Crash alerts through activated signage and 511 or Star 1 mobile phone service.
- Activated signage to report parking availability and next train arrival at Anderson and other transit stations.

ITS technologies such as detectors and closed circuit TV (CCTV) surveillance are being implemented on a wider basis in Massachusetts. This equipment will be integrated into the existing MassHighway Traffic Operations Center in South Boston, which was developed as part of the Central Artery/Tunnel Project. MassHighway already has systems in place that would utilize the information from this equipment. In addition, the state is working on the Mass 511 system, a real-time motorist information using driver cell phones. When the 511 system is in operation, it would provide traffic information that motorists can utilize and take appropriate actions. Real-time traffic information would result in a better and more efficient transportation system usage for both highway and transit.

Regulation of Vehicle Entry

Computer programs ("algorithms") have been developed and are in use in some places in the United States, to improve the flow of traffic on expressways by metering the rate at which traffic enters the highway. It is often referred to as "ramp metering". These approaches:

- Can help traffic flow on roadways operating near capacity like Route 128.
- Need to be implemented on a wide area basis to be effective.
- Require room to store vehicles awaiting entry on ramps.
- Only work if drivers obey the entry signal; enforcement would be a problem.

While ramp metering has been used in the United States, its deployment has been quite spotty, and it has not been used in the northeast. To be effective, ramp metering needs to be deployed at every interchange along a significant portion of a freeway facility, for example, Wakefield to Waltham on Route 128. If just one interchange is provided with ramp metering, it is likely to encourage the greater use of local streets by motorists to avoid the particular interchange with metered entry.

The biggest reason why ramp metering has not had widespread deployment in the northeastern United States is due to queuing, and the I-93/I-95 regional focus area is typical of conditions in the northeast. Ramp metering inevitably results in queues on the ramp leading up to the freeway; (it would not be needed if vehicles arrived at a rate that could be easily assimilated by the expressway interchange). If the ramps are not sufficiently long, the queues will spill over to the local streets and impact traffic operations on those streets. Most of the existing ramps within the study area have relatively short lengths making them inappropriate for ramp metering application, and the densely developed context makes it difficult to lengthen the ramps; the ramps at Mishawum Road, Washington Street, and Route 28 are examples. Metering is not appropriate for the ramps within the I-93/I-95 Interchange itself because traffic enters the interchange at high speed and metering would lead to rear-end collisions. Despite the apparent drawbacks, it is worth looking at the metering option for local interchanges in a regional level study to determine if these issues can be addressed at enough of the local interchanges to make the system effective.

Variable Speed Limits

The amount of traffic that can be processed by a highway varies with the density (spacing) of the vehicles and their speed. Faster is not better in terms of getting the most vehicles through a highway segment, because drivers increase their spacing as they go faster. This can be observed in heavy traffic conditions, in which the "fast lane" on the left often experiences more stop and go than the "slow lane" on the right. Computers using remote sensors can calculate the optimum speed and display it on variable message signs. Key points:

- Variable speed limits in operation in a number of locations in Europe.
- Very cost-effective way to increase highway capacity without construction.
- Some safety benefit by reducing stop-and-go crashes.
- Only works if drivers obey the entry signal; enforcement would be a problem.

The concept of variable speed limit (VSL) is not new in the United States. The New Jersey Turnpike has used it since the 1970s. In general, variable speed limits can be used to warn motorists of hazardous conditions such as fog, etc. or in roadway construction zones. However, variable speed limits for the purpose of optimizing traffic flow both in the US and around the world are new and haven't been completely assessed. In one instance in Michigan where VSL was tested to control speeds upstream of congestion, no major changes in speeds were observed. To be effective VSL would need to be deployed throughout the Route 128 and I-93 corridors. Similar to ramp metering, these ITS strategies cannot be used to solve problems at an isolated location, but they may be effective if they are installed on a system-wide basis.

Recommendation 8.
A study of long-range ITS improvements should be undertaken to address information systems, ramp metering, and variable speed limits as potential techniques to better manage congestion on the region's expressways.

4.4.2 Extending High Occupancy Vehicle (HOV) Use in the Longer Term

The transit and TDM components of the I-93/I-95 package of recommendations work to relieve the highways of congestion and improve mobility by transporting more people in fewer vehicles. There are additional measures that could be implemented in the longer term, based on a forward looking regional HOV study.

- Increasing the share of HOVs in the regional highway and rail transit systems can contribute significantly to reducing greenhouse gas emissions and conserving energy.
- HOVs also have benefits for regional air quality.
- Increasing HOV share increases the capacity of highways to transport people, which is the fundamental measure of mobility.

Increasing HOV use (both multi-passenger automobiles and buses) can be accomplished by extending the measures proposed in the I-93/I-95 recommendations package for Transit and TDM. However, one constraint on the acceptability of HOVs is that trip time is limited by the congestion on the highway system. A well-known measure to improve trip time for HOVs is to provide HOV lanes. An example is the contra-flow (reversible direction) HOV lane on the Southeast Expressway and the HOV lane on the I-93 approach to Boston.

Route 128 west of I-93 and I-93 from south of the interchange to Boston are the primary candidates for HOV lanes in the long term. (Route 128 east of I-93 will be less congested). Because these highways are closely bordered by homes and businesses, widening to provide HOV lanes will be difficult and expensive in most areas, so the more likely course of action would be to convert one of the existing lanes to HOV-only use.

There are three potential forms of HOV systems

1. Fully separated as in I-84 north of Hartford CT - needs very wide highway right-of-way.
   - **Advantage:** most efficient with best operating speeds.
   - **Disadvantage:** requires major right-of-way takings and impacts of multi-level interchanges.
2. Left lane restricted to HOVs, but all traffic mixes at the interchanges - this is less efficient but workable when the demand for HOV use increases to the point that significantly more people are carried in the HOV lane than in the general purpose lane converted to HOV use. Nonetheless, developing acceptability by the motoring public is essential.
   - **Advantage:** possible with little or no takings and at low cost.
   - **Disadvantage:** HOV traffic must weave across other lanes to enter and exit; public must accept conversion of general purpose lane.
3. Express HOV lane with interchanges only at major highways like I-93, Route 3 in Burlington, and Route 2. This system separates the HOV lane by a median or barrier that allows HOVs to enter or leave at longer intervals suited to bus service and longer commuting distances, but it increases the speed and efficiency of the system for these users. A similar system exists on I-271 east of Cleveland OH, but is used for mixed HOV and SOV express traffic.
   - **Advantages:** possible with little or no takings; more efficient than non-express HOV.
   - **Disadvantage:** HOV traffic must weave across other lanes to enter and exit but less frequently than above; public must accept conversion of general purpose lane.

Recommendation 9.
Because of the scale and complexity of the problem and because of its importance to long range mobility, energy conservation, and greenhouse gas reduction, a long-range regional HOV study is recommended.

4.4.3 Land Use Policy

Transportation needs are closely connected to land use. Higher density and mixed land use types are most easily served by public transportation, bicycling, and walking. Low density land use patterns with places of employment separated from residential areas foster the choice of single-occupant vehicles, and this mode choice is further reinforced by factors ranging from free parking at places of work to individual life styles. The result is growing traffic volumes on the region's roadways.

The Metropolitan Area Planning Council (MAPC) is developing a regional plan called MetroFuture, based on an extensive public involvement effort with citizens, planning boards, and other local officials. Scenarios have been developed, ranging from no change in policies to extensive changes in growth patterns, housing, education, water conservation, and transportation. A moderate change alternative has been tentatively selected and is being advanced. This "little by little" alternative encourages development in compact areas that can better be served by transit, and mixed land uses that offer more people short commutes to work and shopping.

Why is land use policy a consideration in the I-93/I-95 Interchange transportation Study?

The I-93/I-95 study is considering and recommending highway and transit/TDM improvements that can be implemented in approximately ten years or less, and it is also considering longer range measures to increase regional mobility and to manage corridor congestion, as described in the preceding sections. Land use policy is intrinsically a long-range measure, because it takes years of incremental change to significantly effect land use patterns; however, the benefits are also long lasting.

1. Land use is important to regional travel patterns, simply because most of regional travel is between different land uses: journey to work, to school, to shopping, etc. Shortening these trips helps to reduce the number of trips using the interstate highways and the I-93/I-95 and other interchanges.

2. Mixed land use on a compact scale shortens these trips and often permits some of the trips to be made by walking or bicycling.

3. Compact land use patterns for both residential and commercial development are more transit-friendly. An example is the recently approved 250-unit development at the MBTA Mishawum Station in Woburn.

Most land use policy is developed locally with leadership by planning boards and aldermanic land use committees. However, the state encourages local land use policies through efforts such as Commonwealth Capital, sustainable development policies, and MEPA review of projects. The state government can work with local decision-makers (ultimately city councils and through town meetings) to implement policy changes through comprehensive planning and zoning and local projects like school construction. Between the state and local levels, regional cooperation and leadership among all members of the metropolitan planning organizations, including MAPC and other regional planning commissions, is critical to coordinating local land use policies.

Recommendation 10.
The I-93/I-/95 Interchange Transportation Study recommends incorporating regional and local land use planning efforts (such as MAPC's MetroFuture initiative) into transportation project planning, and encourages the full participation of Reading, Stoneham, Woburn, other local communities, and regional organizations in the planning process.